PROCEEDINGS

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1877-78.

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ESTABLISHED 1821.

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PRESIDENTIAL ADDRESS

ON

SOME QUESTIONS IN WHICH RECENT RESEARCHES IN SCIENCE ARE TENDING TO MODIFY THE OPINIONS OF GEOLOGISTS.

DELIVERED BY

ROBERT YOUNG, Esq., C.E.

On November 6th, 1877.

When the post of President of this Society for this Session was so warmly pressed upon me by the Council, I was very reluctant to accept it, not that I did not highly value the honour to be conferred, but I felt my unsuitability for the office, and feared that from several causes, and amongst others from the want of due leisure, I should be unable to prepare an opening address such as you have been accustomed to hear from the lips of my predecessors in this Chair. My scruples however were overborne by the kindness of I fear too partial friends; and seeing looming before me the inevitable opening night, I began to cast about for a subject on which I might venture to offer you some remarks. I felt that it should be one with which I had some practical acquaintance, however slight, and with the literature of which I was somewhat familiar. This has led me to decide on directing your attention this evening to some topics having a geological bearing, and this I propose to do more by way of indicating the tendency of modern thought, in connexion with some of the yet unsettled problems of the science, than to put forward any theories of my own.

But now, before I enter on my subject, I must ask to be allowed a few minutes' pause to offer a faint tribute of gratitude and affection to the memories of two men whose names come to my lips when I enter this room, who were long and honourably connected with this Society, and whose labours in the field of local geology, many years ago, gave an impetus to the progress of this science of which the influence is still recognized amongst us. Need I say that I refer to James Mac Adam and James Bryce? Although the systematic and detailed examination of the geologic formations of the country, now being carried out by a staff of trained men fully equipped with every appliance that modern science can supply, may yield results that make the gatherings of the earlier workers seem to have shrunken to a lesser bulk than they once had, let it not be forgotten that what they achieved was done by them as pioneers in an almost untrodden field, single handed, by great personal exertion and expenditure of their own resources. For myself and some of the few Academy boys I still occasionally meet, and with whom I talk about our old school days, I can say that one and all of us refer any tastes we have for the Natural Sciences and our love of Nature in her varied aspects, firstly, to the Natural History lessons of James Bryce, but secondly, and above all, to our Saturday half holiday rambles, when, with our teacher as "guide, philosopher, and friend," we scoured the hill sides, searching every glen and quarry for fossils, minerals, and plants.

He was Secretary for this Society for many years, and only severed his connexion when he went to Glasgow in 1846, to enter on a wider field for his abilities, as Master of the Mathematical and Geographical Department of the High School in that city. There for 27 years he laboured successfully to carry out the ideas he first put in practice in this town, of teaching the Natural Sciences as a part of ordinary school work. During his vacations, generally accompanied by some friend, and hammer in hand, he pursued his favourite studies among the rocks in various parts of the Highlands of Scotland and the North of Ireland, and these researches resulted in many valuable papers on the geology of the districts so examined, which were contributed to the Geological Society of London.

After retiring from his scholastic duties a little more than three years ago, he went to live in Edinburgh, but still continued his wonted field-work in the Highlands. In July last, he started with seemingly unabated energy to complete the examination of a part of Sutherlandshire, and Rosshire, on which he had been occupied for several years. I had been with him there in 1876, and we had arranged to meet again this year, and on our way to examine the terraces at Aughnasheen, but alas! this was fated not to be. The sad accident by which he was deprived of life must be known to you all;—to be struck down whilst engaged in the pursuit of his earliest and favourite study, was not an unfit ending to a long life devoted to science.

To turn now to some of the questions in which scientific research is tending to modify the opinions of geologists, the most prominent seems to be that of the "UNIFORMITY OF CAUSES."

When I speak of the opinions of geologists, I refer to those so ably expounded and illustrated by Sir Charles Lyell in his famous "Principles," published many years ago, though the 11th edition is so late as 1872; and I do so, because this book has been almost universally accepted as the most philosophic and reliable work that has yet appeared on the subject of geology.

One of Sir Charles's strongest positions, and the one in which he and his followers, as opposed to the school of Catastrophists, seem to place their chief reliance, is the theory of the "uniform nature and energy of the causes which have worked successive changes in the crust of the earth, and in the condition of its inhabitants." No doubt these views had been quite honestly and fairly arrived at, considering the state of scientific knowledge up to that period. But the whole aspect of this question has been changed by the recent speculations of Sir William Thomson and others, as to the rate at which the sun and the earth have been cooling—in fact since the ideas of the conservation and dissipation of energy have been taught by the new school of physicists.

As closely related to this subject, I would here notice the theories of earthquakes and volcanic energy proposed by Mr. Robert Mallet. These are the outcome of his most elaborate and careful observations and experiments extending through many years, and are said, by those best qualified to speak, to be masterpieces of exact reasoning. In presenting him with the Wollaston Medal, in February last, the President of the Geological Society having characterised his works on "Volcanic Energy as being full of admirably elaborated facts, and propounding a theory, whose truth may be fairly estimated by the attention it has received," concludes a warm eulogium by saying, "He has done the greatest service to geology, in directing the thoughts of scientific men towards the cosmical relations of the grandest phenomena of the globe, and their possible explanation by thermo-dynamics."

In respect of earthquakes, the most important point he has established, is the very moderate depth of the focus of motion below the surface of the earth. The first earthquake ever submitted to measurement was the great shock at Naples, in 1857, and here he was able to determine, both by observation and experiment, that the impulse began at a point from 8 to 9 miles only under the surface.

His theory of Volcanic Energy, given to the world in 1872, has exercised the geologic mind even more than Sir William Thomson's speculations. The gravamen of this theory is what may be stated thus: "The heat from which terrestrial volcanic energy is at present derived, is produced locally within the solid shell of our globe by transformation of the mechanical work of compression or crushing of portions of that shell, which compressions and crushings are themselves produced by the more rapid contraction by cooling of the hotter material of the nucleus beneath that shell, and the consequent more or less free descent of the shell by gravitation."

By experimentally crushing one cubic foot of various rocks, Mallet found that the heat developed in the process was sufficient to fuse 0·108 or say $\frac{1}{10}$ of a cubic foot of the same rock—that is, to melt one volume of rock it will be necessary to crush ten volumes.

Now, in connexion with these conclusions, we should note the equally important ones enunciated by Sir W. Thomson last year at the British Association at Glasgow, which seem on one point to lend strong support to Mallet's views.

As the result of a chain of reasoning founded on the law of the "secular cooling of the earth" and other considerations, he confirms the conclusion of Hopkins "that the earth is practically a solid body; that whatever part is liquid, whether it be melted matter in the interior, or the waters of the ocean on its surface, it is insignificant compared with the whole; and that we must reject any geological hypothesis which for the purpose of explaining underground heat, ancient upheavals, and subsidences of the solid crust, earthquakes or volcanoes, assumes the solid earth to be a shell resting upon an interior liquid mass."

These views could not but prove startling and unpalatable to many who had placed their trust in the teachings of Lyell and De la Beche, and had hitherto been shutting their eyes to the new light of the physicists. How hard it is for such men to abandon the dogmas of "uniformity of energy," and of the liquid interior of the earth, may be judged when we find an accomplished practical geologist such as Mr. Judd giving expression to his vexation when, in his recent treatise on volcanoes, he refers to the "tendency of those who abandon these safer methods of inquiry based on the doctrine of uniformity, and revert to the earlier methods—in effect to the substitution of *cosmogony for geology*." This sneer is probably aimed at Professors Sir W. Thomson and Tait, but Mr. Robert Mallet is still more severely taken to task for his speculations. He says of him, "that adopting a still bolder course, and almost entirely ignoring the results of geological inquiries, he endeavours to build, upon the foundation of the Nebular Hypothesis of Laplace, and by the aid of those laws of physics which he believes as fully established, a system of Vulcanicity." This is doubtless the feeling of many of those who have overlooked the reasonable claims of the physical aspects of their science. But this feeling of irritation must soon pass away; and it will then be admitted by all, that such speculations as I have referred to, have their legitimate and necessary place in the progress of a science so eminently complex, progressive, and cumulative as geology.

Whilst enormous stores of observed facts are being rapidly gathered from every quarter of the globe by the labours of the field geologist, who may do this part of the work admirably whilst neither a chemist or a mathematician, it will still remain as hitherto for a select few who have been gifted with minds of the highest philosophic grasp, and who have been specially trained to the work, to systematize and deduce from these facts the theory that will go nearest to satisfy all the observed phenomena. A completed science of geology is therefore neither to be expected, nor is indeed possible, until all the subsidiary sister sciences which depend upon the accumulation of observations of natural facts have been themselves completed. Finality is as little to be found here as in the science of politics. In both there must be progression, at times very slowly, but still progress; and in the one as in the other, periodic readjustments to altered conditions are inevitable, and should be acceded to with a good grace.

Let us glance then at some of the readjustments of our notions that seem to be demanded by the law of the dissipation of energy.

If the sun is losing heat, of which this earth receives a part, and if that again is expended in doing work, such as raising water in the form of vapour, which falling in rain wears down the rocks and carries the detritus into the seas; and if this waste of heat goes on continually from day to day passing into space, as heat and work are in very close relation, we must abandon our notions of the "uniformity of the energy" which has been put forth in the denuding and conversely in the regenerating forces throughout the course of geologic history.

The only attempt I have yet seen to present a complete notion of the consequences of this is a recent paper, entitled "Evolution in Geology," in the Geological Magazine, by Mr. Sollas, F.G.S., Lecturer at Cambridge, from which I now summarise the following particulars.

The rate at which the earth has been cooling down from the time at which it was first covered with a solid shell has been roughly calculated by both Thomson and Tait, the former placing this epoch about 150 millions of years ago, and the latter about 50 millions of years; now taking the mean of these, or 100 millions, a scale for rate of cooling has been calculated in terms of the increase of temperature for each foot of depth in the earth below the mean permanent temperature level, and starting with the present ascertained rate of increase as one-fifth of a degree F. for each foot of descent. Going back 96 million of years, or 4 millions after the crusting-over epoch, it would be one-tenth of a degree for each foot; at 160,000 years after the same first point of time, one-half of a degree; at 40,000 years one degree, and at 10,000 years two degrees for every foot descended into the earth.

Now the calculations that geologists have been led to make of the time that has been occupied in depositing all the beds of rock that are known to them, commencing with the earliest Laurentian series, to the present time, are naturally very vague and differ widely from one another; but even if we take the very low estimate of fifty million years, there must have been an enormous excess of potential energy both in the earth and in the sun, and therefore far more energetic geologic action in the early history of this planet than at the present time.

1. The waste of the land depends on the amount of rainfall, and that again upon the difference in temperature between the poles and the equator, and the earth and the higher parts of the atmosphere. Owing to the greater radiation of solar heat, the earth must have had a much higher temperature in the early geologic epochs, and there must have been also a much greater difference of temperature between the poles and the equator, and similarly between the surface of the earth and the higher regions of the air. From these causes there would arise increased evaporation and a larger rainfall. From this would follow a more rapid wearing down of the surface of the land, and digging out of glens and valleys, and it is obvious that the reconstruction of rock in lakes and seas into which the waste from the land would be swept down, would just keep pace with the denudation.

2. The influence of springs would be not only increased by the more copious rainfall, but the greater temperature of the earth's crust would very largely enhance their action, as we have seen that even 10,000 years after the solid shell was formed, water percolating into the ground would, at a depth of 51 feet, attain a temperature of 102° F., whereas at present at this depth it only reaches 1° F.

3. As the action of the winds depends likewise upon the difference of temperatures, if this difference be increased as it seems it was, there must have been greater energy and power of wasting the coasts imparted to the sea waves and to the drifting sands.

4. Again, as the tides depend upon the action of the sun and moon on the rotating mass of the earth, and as the rotation must have been more rapid the further we go back, the tides must have had greater energy. If we conceive the velocity of rotation doubled, we should have twice as many tides in the same time, and each of these would have greater velocity and corresponding energy, so that the tidal currents would do more than double, probably three times, the amount of work upon the coast line, in wasting and shifting the debris to other places, than they do at present.

5. Marine currents, which are known to depend on the same differences of temperature as the winds, would obviously have their energy for transporting silt largely increased.

6. The change which the earlier sedimentary rocks have undergone, and which is generally called metamorphosis, was unquestionably the result of their being exposed to great heat, and it is evident that this was much more easily attained at early periods ; for example : After 160,000 years of permanent rock crust, the increase of heat for each foot of descent is half a degree, therefore a depression of rock formations 20,000 feet below the normal level, which is but a trifling amount of change, would give an increase of 10,000 degrees, which would be enough to melt and reduce them into a molten mass in the interior.

7. As the formation of heights and hollows on the crust of the earth are generally admitted to be due to the wrinkling or

breaking up of the crust on a contracting nucleus as the earth cools down, it is evident that when the cooling was much more rapid, the movements of elevation and of corresponding depression must have followed each other with greater rapidity than at the present time.

It would therefore follow that if these views are correct in their main scope, and they seem to me to be irrefragable, the old estimates of the amount of time during which certain rocks were formed can no longer be relied on. What is wanted now is the determination of a sliding scale of geologic time proportional to the energies of the geologic forces that were at work from the earliest epoch to modern times ; and then, according to their stratigraphical position in the series, we might estimate, at least approximately, their relative and (with of course much less approach to certitude) their real age, and also the period of time occupied in their formation.

It certainly appears to be a strong corroboration of the theory of greater rapidity of rock formation in early epochs, that, as Professor Phillips has observed, fossiliferous strata increase in thickness in proportion to the paucity of fossil species they contain, the Cainozoic rocks containing about four times the number of species that are to be found in the Palæozoic strata.

To come now to another question which has given rise to much controversy, viz.,—the cause of the cold climate that must have prevailed in this and other countries of Northern Europe and America at the beginning of what is called the Glacial period.

That the preceding was a lengthened period of high temperature is evidenced by the remains of plants found in carboniferous, cretaceous, and tertiary rocks within the Arctic regions.

Lyell seems to have inclined to the view that the change of climate which brought in the Glacial period had its origin in a moderate amount of geographical change in a very high latitude, such as the increased height of part of the land now between 70° and 78° N. latitude, and the addition of some islands near the pole. He thinks this much more likely to have intensified the cold in both the Eastern and the Western hemispheres than a change in the eccentricity of the earth's orbit. However, the theory of Mr. James Croll, which is founded on a consideration of the increase in the eccentricity of the earth's orbit, *coupled with a variation in the obliquity of the ecliptic*, has been thought by many geologists to offer a more probable cause.

By a number of elaborate calculations founded on Leverrier's formula, Mr. Croll has determined the periods for one million years back, when there was the greatest eccentricity, and the largest number of winter days beyond the normal. He then argues that with the maximum eccentricity, the cold would be intensified in the hemisphere in which winter occurs in aphelion. All the moisture would fall in snow instead of rain, and whilst he admits that the heat in the same hemisphere in perihelion would be proportionately great, he asserts that although at first the intense heat would melt the winter ice, yet very soon fogs would be raised which would prevent the further action of the heat.

A distinguished member of this society, who has lately occupied this chair, Mr. J. J. Murphy, has in my opinion ably and clearly pointed out the fallacy of this theory, and given good reasons for the converse view, viz.,—that with the maximum eccentricity of the orbit the hemisphere which has its winter in perihelion and summer in aphelion is the one which will be glaciated, because the effect of the summer heat in removing the ice and snow will be reduced to a minimum.

Some light seems to be thrown on this important question from a new and unexpected quarter, and it is another proof of the material aid that can be given by one branch of science to the others. Mr. Edward Carpenter of Cambridge has lately called attention to what he thinks is an analogous condition of things on the surface of Mars—a planet about which more than ordinary interest is being now exhibited, and the phenomena he refers to seem to confirm Mr. Murphy's views in a very striking manner.

Mars has an orbit rather more eccentric than the earth's. Sir J. Herschel gives it at ·0931, Leverrier's estimate of maximum for the earth's, is ·0707. The inclination of the axis of Mars to the perpendicular to the plane of its orbit is also somewhat greater than the inclination of the Earth's axis to the plane of the ecliptic ; but in addition to these coincidences, there is, curiously, a third point which completes the analogy. In the northern hemisphere the winter solstice is at present in perihelion, and the summer solstice in aphelion, and in the southern hemisphere the converse of this prevails.

The year of Mars has 687 days against our 365 days.

The way in which land and water are distributed in the two hemispheres of Mars is more nearly equable than with us, and the land area exceeds that of the sea three to four times. There would therefore seem to be as far as possible no geographical cause of variations between the poles of Mars, and whatever differences are found to exist may be fairly referred to astronomical causes alone.

The results of careful observations on its snow caps, show that although they are at their maximum of almost equal extent, their changes are very remarkable. That at the northern pole changes but little and slowly, that at the southern pole much and rapidly. This seems to confirm Mr. Murphy's view that, *cæteris paribus*, the glaciated hemisphere will be the one that has the *moderately* cold winter and *moderately* warm summer, and not the converse, of the one having excessive cold in winter and excessive heat in summer.

If we apply this to the calculations of Mr. James Croll to determine the probable date of the Glacial period, the results of which are given in Lyell's "Principles," we see at once where their error lies. His object was to find the periods in long-vanished ages, when the largest excess in the number of winter days would arise from the winter being in aphelion. It looks as if the calculations should now be revised so as to fix the periods when there were the coolest summer days, arising from the *summer occurring in aphelion.*

Still it must be admitted that the speculations of Croll have opened up a very wide field for inquiry in respect to the epochs at which ice action may have played an important part in early geologic history, and probably at far earlier epochs than he has sought to determine.

Sir Charles Lyell hints that there may be periods in the newer Pliocene and Post Tertiary, deserving the appellation of Glacial, and Professor Ramsay thinks he has discovered evidence of ice action in the Permian strata. But it need not surprise us if a more careful scrutiny than has yet been applied to some of the older rock formations where they have not been too much changed by heat, may yet yield undoubted evidence of the action of ice even in those remote times. The evidences of glaciation should be sought in the characteristic markings on the upper surface of strata on which conglomerates rest, and the pebbles contained in these latter may also be expected to exhibit the well known signs. It is stated that already some undoubted ice scratchings have been found on pebbles in the old Red Sandstone of Scotland, but I am not aware of any account having being yet published.

I have now to notice a subject which has cropped up recently of quite an opposite character, yet probably connected indirectly with the last.

Whilst in this happy land of moderate heat and moisture, we have generally to complain of the superabundance of the latter, and popular opinion inclines to the belief that the rainfall is greater than it used to be, it would appear that in some other countries the opposite tendency is strongly exhibited, and the dwellers therein complain of increasing drought.

In a late number of the "American Naturalist," Professor J. D. Whitney has brought together some very striking facts, leading to the conclusion that a CONSIDERABLE PORTION OF THE EARTH'S SURFACE IS DRYING UP.

There has been for centuries a wide spread belief, that the countries bordering the Mediterranean are drier than they were two or three thousand years ago, and that this arises from the felling of the old forests which are assumed to have existed there; but it is hard to find much direct proof either of the general denudation of the timber, or of the climate having undergone any very marked change; as any records of the rainfall for a sufficient time are entirely wanting. As regards two limited areas, Palestine and Greece, there would seem to be not much doubt that they have experienced a very marked climatal change within the historic period. The traveller in the Holy Land finds it hard to realise in its now desolate and arid limestone hills, the goodly land of brooks and springs, and flowing with milk and honey; and when he visits Greece he is shocked to find the Ilyssus only an insignificant rivulet.

If there is difficulty in getting reliable evidence of such changes in early historic times over a wide extent of country, there exists none with regard to more recent periods; and in most instances these changes are continuous to the present time. There are two immense regions, one in the Old World, and the other in the New, where all the recent observers concur in their belief that there has been a very great reduction in the amount of water existing on the surface. One of these is Central Asia, and the other Western North America. The recent observations of the travellers Schlangenweit, in Thibet and Turkistan, tend in this direction. As regards the former region throughout all parts of the great plateau both north and south of the main watershed, and everywhere through the great hollow between the Himalayas and the Karakorum watershed, they found the evidences of mountain lakes having formerly existed. They saw in Western Thibet that evaporation is in excess of supply, and consequently there is a general and progressive decrease of water surface throughout that region.

In a recent work by Mr. Drew on the Jummoo and Kashmir territories, very ample proofs are adduced for confirming the idea that the beautiful vale of Cashmere was in quite recent geologic times occupied by a lake, and the tradition of the natives makes it probable that the drying up occurred in historic times. The most important contributions to the body of evidence on this subject of the drying up of whole countries, have been made by the recent researches of Major Wood in the districts of the Aral and Caspian Seas. There is now ample proof that the areas formerly covered by their waters has been greatly lessened during late geologic epochs, and that this diminution has continued into quite a recent period—in fact, is still in progress. There seems to be sufficient grounds for believing that there was in this part of Asia, and at no very remote time, a vast sea on a level with, and connected by navigable straits with, the Northern Ocean.

In Northern Africa, the very extensive ruins lately discovered in the Great Libyan Desert, certainly seem to point to a very marked change of climate in recent times, as the entire district is now a dry, parched land, and totally destitute of inhabitants.

In his wanderings in Southern Central Africa, Dr. Livingstone very often refers to the proofs he saw of the great and apparently rapid reduction of the volume of the rivers and lakes in quite recent times, in the districts he traversed.

It appears that a similar condition of things is found to prevail throughout a wide region in North America, and most notably in the district called the Great Basin, westward of the Rocky Mountains. The Great Salt Lake of to-day is evidently a mere shadow of what it once was, when its waves washed the highest of the remarkable terraces which surround it; yet competent observers assure us that the sharp and well defined contours of these terraces show that the drying up of the waters must have been within comparatively recent times.

To pass from lakes to rivers, there is a very general opinion on the Continent that the volume of several of the large rivers of Europe has decreased within historic times. For example, the condition of the Elbe, the Oder, and the Rhine, have been investigated in connexion with this subject by Berghaus, who arrives at the conclusion that they have all decreased in volume within the last one hundred years, and fears are expressed that they may cease to be navigable. A somewhat similar report has been given by Carl Wex in respect to the Danube. In these cases the continental savans consider, apparently with good reason, that the removal of the forests at the upper sources of the rivers is at least one of the causes. This cause is however plainly inadequate to account for such wide areas of progressive desiccation as we have seen are to be found in Asia, Africa, and North America. All the conditions in these regions absolutely exclude this idea of man's action on Nature having had any appreciable agency in the production of the phenomena. Professor Whitney has offered no theory in explanation, but promises at a future time to explain the connexion between the glacial epoch and the present one of desiccation.

THE "CHALLENGER" EXPEDITION.—We cannot overlook the important result that the expedition of the "Porcupine" first, and lately of the "Challenger," have had in explaining several of the hitherto obscure problems of the formation of rocks in the deeper parts of the ocean.

Although deep-sea soundings were begun about twenty years ago, when the preliminary survey for the Atlantic cable was made, it was only during the expeditions undertaken at the instance of the Royal Society, and in which our old and distinguished associate Sir Wyville Thomson has had so large a share, that the newer methods and appliances for investigating the profundities of the ocean can be said to have been used.

These soundings of the "Challenger" should have a more than ordinary interest for us, considering our geological surroundings. We can now form a more adequate conception of the conditions under which our chalk beds of County Antrim, with the underlying strata, must have been formed. We can now see that down to a certain level, the whitish mud and ooze was derived from the calcareous shells of minute creatures that lived in the uppermost 100 fathom stratum of the sea, and how at a greater depth than 2,000 fathoms, the white ooze which is just incipient chalk, gives place to red clay, which is thus forming beds of prodigious extent in the great ocean valleys.

Sir Wyville seems to have no doubt that this red clay is the ash or residuum of the Globigerina ooze after the calcareous matter has been removed in some way not understood yet. Is it possible that it was in this way that the thick beds of non-fossiliferous clays were derived?

I have always felt that it was a great puzzle to say from the waste of what old formation the marls of our Triass could have been derived.

The entire absence of fossils in our series of local sandstones and marls is probably due to their having been deposited in an inland sea, at first of considerable depth, and separated by a barrier from the great oceanic thermal circulation which Dr. Carpenter has shown to be absolutely required for marine life.

That there must have been subsequently a great elevation in this sea bed, continuing to the period that the upper sandstones were being deposited, is very evident from the frequent occurrence among them, and notably in those brought from the County Down quarries, of many thin layers of fine clay intercalated with the sand, which exhibit in their reticulated and almost prismatic structure the obvious effects of shrinkage in drying. This shows there must have been a series of submergences and alternate exposures of the surface to the air, such as occurs on the foreshore of all tidal seas at present. Some years ago I found rain-drops on a freshly exposed surface of the rock at the Scrabo quarries.

Besides these proofs, we have the further evidence of the ripple markings on many of the beds, which are usually covered by a thin film of clay, giving conclusive proof of the shallowness of the sea. It occurs to me that if it can be shewn, what is at least probable but not quite proved, that the entire shrinkage of one of these laminæ was completed in one interval of tides by the sun's heat, we have had laid up for us in these stony tablets a contemporary record of the energy of the sun at that period, which it only requires the science of a Thomson or of a Mallet to formulate; and this modulus again may help in some way to determine a scale of time for geologic evolution.

With regard to another obscure subject, the origin of green-sand, and the green covering found upon fossils in our chalk beds, light has also been thrown by Dr. Carpenter's researches. He shows that green-sands are in process of formation along the line of the Agulhas current and along the coasts of Australia, and that they consist almost entirely of the internal casts of foraminifera, the sarcode being replaced by glauconite, and the calcareous shell being dissolved away under enormous pressure. We may therefore assume that our green-sand and *mulatto* beds were formed in depths exceeding 12,000 feet, and that these had been elevated when the upper chalk was being deposited. Professor Church has still further made clear how this glauconite is derived, by his discovery of magnesia and potash in the residue of red chalk, which he has found to be the equivalent of the red clay of the deep sea, and he points out that the Globigerina ooze may in one instance have yielded the red clay deposit, and in another glauconite, according to differences in the dissolved gases and salts in the ocean, and the nature of the prevalent animal life.

To come now to an epoch nearer our own:

Cave hunting, in connexion with geological research, has of late years been prosecuted with much zeal, and the now scientific examination of the contents of bone caverns in various places has gone very far towards settling questions respecting the date of man's appearance on the earth.

In many of these places the bones of men, with their rude flint implements, are found embedded along with the remains of extinct mammals, such as the Mammoth, Irish Elk, and Cave Lion.

In the caves examined in the Dordogne, in the south of France, have been discovered the earliest known evidence of the graphic art of man, in the shape of highly characteristic sketches of reindeer cut upon flat pieces of bone, which are now to be seen in the Museum of Paris.

It is interesting to know that in a quite recent exploration of Robin Hood's cave in Derbyshire, in the lowest layer of cave earth, was found a fragment of bone having engraved on it a well-drawn outline of a horse's head and neck. In the same stratum was a tooth of the extinct Machairodus latidens, of which the only other example is from Kent's Hole, numerous implements of flint and quartzite, and immense numbers of bones of pleistocene mammalia—Cave Lion, Leopard, Spotted Hyena, Reindeer, Irish Elk, Bison, Woolly Rhinoceros, Mammoth, Fox, Wolf, Bear, Hare. In the superficial layer were the remains of Romano-British occupation, resembling those described by Mr. Boyd Dawkins in the exploration of the Settle Cavern, Yorkshire.

At the late meeting of the British Association at Plymouth, the Devonshire caves had a large share of attention. Mr. Pengelly stated as the results of the explorations at Kent's Hole, carried out under his own personal superintendence, from 1865 to this time—"that there has been not only a complete confirmation of Mr. M'Henry's statements, but the discovering of far older deposits than he suspected—deposits implying great changes of at least local geographical conditions; changes in the fauna of the district; and yielding evidence of men more ancient and far ruder than even those who made the oldest flint tools found in Kent's Hole prior to 1865."

The statements of Mr. M'Henry, made about 1841, that he had found flint implements mixed with the remains of extinct mammals, were scouted by the scientific men of that day. We have now the President of the Geological Section giving it as his deliberate opinion, "forced upon him," he says, "by the present state of the evidence, that the earliest men of Kent's Hole were *inter-glacial* if not *pre-glacial*."

Accurate observers in other quarters have been arriving at similar conclusions.

Mr. James Geikie, Chief Director of the Geological Survey of Scotland, assigns all palæolithic implements and the associated Fauna to the interglacial period. He thinks the palæolithic deposits began after the Great Scottish Ice period, and that the subsequent submergence of the land has been the main cause of the sweeping away from many areas of the remains of men and animals that inhabited them in the interval succeeding the glacial period.

But still further progress is being made, and several facts have lately been adduced, which make it at least highly probable that some of the palæolithic implements may be of *pre-glacial* age. This evidence has been briefly summarised by Mr. Tiddeman, in *Nature*, October 5, 1876:—

1. A Human Fibula found in Victoria Cave, Settle, under glacial till, associated with Elephas antiquus, Rhinoceros leptorhinus, Hippopotamus, &c.

2. At Wetzicon, Canton Zurich, a piece of lignite containing

basketwork, lying beneath glacial deposits, and associated with Elephas antiquus and Rhinoceros leptorhinus; and above the glacial till a river gravel, upon which are huge angular erratic blocks indicating the presence of a great glacier, posterior in date to the organic remains.

3. Near Brandon, in Suffolk, Mr. Skertchly has found in the lower till, or brick-clay, chipped flint implements of the earliest and rudest type, associated with bones not yet determined, and covered by the great chalky boulder clay of that district.

With these I must now correlate some facts of a similar kind observed in our own district, and reported by myself to this Society, and by Mr. Knowles to the Naturalists' Field Club eight or nine years ago.

The earliest find was in July, 1867, when in excavating a mill reservoir in the alluvium at the junction of the Clowney stream with the Blackstaff, after passing through a stratum of estuarine silt and shells at a depth of 15 feet from the surface, an immense accumulation of bones and horns of the ox and deer were found; these were mixed with the trunks and branches of small trees, some being yews, and coarse subangular trap gravel, and imbedded with them were found a wrought deer's horn and a wrought rib bone which I now exhibit. The cuttings on both are exactly what would be done by flint saws, such as have been found elsewhere in various places. These seem to me to point conclusively to the opinion that palæolithic man inhabited this district when the country was at least 25 to 30 feet lower than at present.

But shortly after this a still more surprising discovery was made, the full import of which I did not clearly apprehend at the time I brought it under the notice of this Society in 1868, when I only ventured to hint at its connexion with an *inter-glacial* epoch. I refer to the discovery of several (six I think in all) large blocks of oak timber embedded in the boulder clay at Dover Street in this town, where bricks were being made. They were about four feet high, rudely squared, about one foot on each side at base, and tapering to eight or nine inches at top, having mortices roughly cut through them close to the base as if to receive a longitudinal waling piece; but the most extraordinary phenomenon of all was that each was found at the same level, standing vertically on its butt, and with not less than two feet of the undisturbed virgin clay passing over its apex. That it was *undisturbed*, I concluded from the careful examination I made in situ of the last of these blocks that was found, and this was confirmed in the strongest manner by the independent opinion of a very competent authority, Mr. James Wallace, in whose brickmaking operations the discoveries were made, that the appearance they presented as he saw them exposed in the cutting, time after time, was only consistent with the theory that they were there first, and the clay was washed about them or dropped on the top of them afterwards.

With the clearer light now thrown on this question of the antiquity of man by such authorities as Geikie, Ramsay, Pengelly, and Tiddeman, for my own part I find it now impossible to avoid the conclusion that these blocks were fashioned and set up here by human agency, and formed the substructure of a house at a time probably anterior to the glacial epoch, but at any rate before the submergence of the land which followed it.

The piece of wood reported by Mr. Knowles as having been found in the boulder clay at Cullybackey, at a depth of 32 feet, and which seems to have been the pointed end of a stake, was clearly pre-glacial; and although some doubt was then thrown upon the other piece of wood and stones from the road cutting at 18 feet depth, being wrought by human hands, the hyper-sceptical stage in this matter, I trust, has now passed away; and we should be prepared to receive every fresh addition to the body of proofs that man was coeval with the glacial epoch.

If I am correct in the date I have assigned to the relics of the house at Dover Street, it must be admitted that it clashes with the generally-accepted theory that, as we go farther backward in time, we find man more barbarous and degraded. This notion seems to have arisen from a very partial and hasty generalization, founded, I think, mainly on some slight differences in the manufacture of the implements found in the earlier deposits, compared with those from the gravel, and without taking into account such facts as the high type of crania of the cave dwellers, found with the oldest implements. Of the very earliest cranium, that found at the Engis cave, Huxley says, "it is a fair average human skull, and might have belonged to a philosopher," and Dr. Pruner-Bey says of other crania from Cro-magnan, that their capacity exceeds modern European skulls, while their symmetrical forms, without any trace of prognathism, compares favourably not only with the foremost savage races, but with many civilized nations of modern times. I think we have in the Dover Street relics a further proof that at the very earliest point of time with which we can associate him, his condition was very far from being so degraded as that of many savage nations at the present day, and certainly, for so far, adding nothing to the probability of finding the lower human types or intermediate forms, for the discovery of which so many are eagerly looking.

In conclusion, I would say to those who have a love for the field work of geology, and I know there are many such here—there is in this neighbourhood plenty of work to be done yet. I do not refer so much to the working out of the fossils in our Silurian and Cretaceous series, for I know these are in good hands; but I speak more of what has yet to be done in examining systematically the more recent surface geology of our district—tracing out and assigning to each agent, whether glacier, or iceberg, or sea-wave, or river, the nature and extent of work that each has done in past ages in sculpturing and moulding and fashioning the hills and vales around us into the forms which now delight us; and along with this there is work to be done in cave hunting at various places, especially among the cliffs along our picturesque Antrim shores; and I doubt not a goodly harvest of palæolithic remains is to be gathered by those who will undertake their examination with the skilled energy that animates a Pengelly or a Dawkins.

4th December, 1877.

ROBERT YOUNG, Esq., in the Chair.

A Paper was read by JOSEPH WRIGHT, Esq., F.G.S., on

FORAMINIFERA, RECENT AND FOSSIL, WITH SPECIAL REFERENCE TO THOSE FOUND IN IRELAND.

IN 1870, Mr. William Gray, M.R.I.A., drew my attention to the fact that he had found Foraminifera in quantity in the Lias shale at Ballintoy. Professor Ralph Tate, F.G.S., had a short time previously recorded Dentalina obliqua, (Linné) from these beds;* he had also noted the occurrence of Cristellaria rotulata, (Lamk.) from the greensand of Cave Hill,† and these two records comprised all that was known of fossil Foraminifera in Ireland up to that date. This discovery of Mr. Gray's was, therefore, of great interest, as he was the first to show the occurrence of these little Rhizopods in quantity in any of our Irish rocks. The Lias at Ballintoy being soft, and fine grained, was singularly favourable for preserving uninjured these minute organisms, and as the shale has the property when placed in water of absorbing it like a sponge, and rapidly falling down in the form of mud, the contained Microzoa can be readily separated from the shale, beautifully perfect, and possessing the brilliancy and lustre of recent species. Twenty different forms were found at this station,‡ and although during the following

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* Rep. Belfast Nat. Field Club, Appendix 1869-70.

† Quart. Jour. Geol. Soc., Vol. XXI., p. 31.

‡ Rep. Belfast Nat. Field Club, Appendix 1870-1.

six years much progress was made in finding Foraminifera in most of the other geological formations in Ireland, no further discoveries were made in the Lias. In 1876 I found that the Lias at Barney's Point, Islandmagee, contained them in quantity, referrible to twelve species ;* six of which were new to the Irish list; and about the same time Mr. Gray announced that he had discovered them at four or five other localities, and it may be presumed that wherever the Lias occurs of a character capable of being washed down, it will be found to yield Microzoa in more or less abundance. I have now to add the name of another species, viz., Vaginulina harpa, (Röm.) ; it occurs plentifully in the shale at Ballygally Head.

About the same time that I was working at the Ballintoy Lias, Mr. S. A. Stewart, F.B.S.E., was preparing his paper on the Estuarine clay fossils of the North of Ireland,† and kindly placed in my hands for examination some fine material from the raised beach at Magheramorne. It contained Foraminifera in abundance, referrible to thirteen species. The clay had been washed through fine sieves with the view of preserving the smaller mollusca only, and not with any intention of giving the record of Foraminifera. In consequence, the larger forms were alone preserved. I have since however re-examined some of the clay taken fresh from the deposit, and have already found 57 other species not given in Mr. Stewart's list. Notwithstanding that the boulder clay usually contains few if any organisms, one or two of the localities have been found to yield Microzoa in considerable abundance. Of these the richest was a thin bed of boulder clay exposed when excavating for the clear water basin at the waterworks. Unfortunately, this exposure is now covered up and no longer accessible. Clay taken from the inside of some Buccinums found at this station yielded microzoa in abundance, but the quantity was too small to give satisfactory results. The boulder clay at Ballygally Head has yielded quite a number of species, though none occur in quantity. The forms are small and poor, indicating conditions not favourable to their growth.

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* Rep. Belfast Nat. Field Club, 1876-7.

† Rep. Belfast Nat. Field Club, Appendix 1870-1.

The white limestone which forms so striking a feature in the landscape of our Antrim coast, is of the same age and character as the chalk cliffs of the South of England, but with us it is hardened by the heat and pressure of the overlying basalt. The chalk of the South of England has long been familiar to microscopists as yielding an enormous profusion and variety of microzoa. With us however the hardness of the stone was an insuperable obstacle to anything being known regarding them. A few forms had certainly been detected in thin microscopic sections of the stone cut by the lapidary,* but little or no progress could be made in their study so long as such a process had to be employed to see them. In February, 1872, I discovered that the soft powdery material frequently found inside the cavities that often occur in flints, being in fact a portion of the old sea bottom of cretaceous times, on being washed and cleaned, yielded microzoa in great profusion.† These tiny forms thus preserved in the flint have remained uninjured by the influences which converted the surrounding ooze into solid limestone. I have myself visited a large number of quarries, and additional material was kindly placed in my hands by Mr. Gray, Mr. Stewart, and Mr. Galloway, and thus I had an opportunity of examining chalk powder from thirty-six localities in the counties of Antrim, Derry, and Down. Among the many specimens collected from these various places, besides Corals, Polyzoa, Sponge Spicules, and Ostracoda, all of which were found in considerable abundance, I recognised one hundred and six species and well marked varieties of Foraminifera, many of these attaining fine proportions, being much larger than those usually obtained from the washings of English chalk. Chalk flints are usually found hard and solid throughout, only a small proportion of them having cavities containing chalk powder. So far as I have observed, those containing the powder appear to be confined to flints that have for some time been exposed to the action of the weather;—the white material frequently seen in the interior of those newly

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* Jour. Roy. Geol. Soc., Ireland, Vol. III., new series, p. 88.

† Rep. Belfast Nat. Field Club, Appendix 1873-4.

quarried being always of a hard nature. Several of the forms found were new to science. One represented a new genus named by Professor T. Rupert Jones, F.R.S., "Ramulina," from ramulus, a little branch. But the discovery of greatest interest was a Rotaline form like Rotalia orbicularis in shape, but having each chamber symmetrically perforated with a large central aperture on the outside. This specimen is of great interest when considered with the few other known open-chambered Foraminifera, being apparently an intermediate link between the Foraminifera and those exquisitely beautiful basket-like siliceous Rhizopoda,—the Polycistina, so familiar to microscopists as occurring in Barbadoes earth.

Professor Ehrenberg states that on the Continent the glauconite in the greensand is composed of the casts of Foraminifera, and Dr. Carpenter asserts that the glauconite in greensand is everywhere of the same character ; at the request of Mr. Stewart I have examined the glauconitic grains so common in the greensand deposits of this locality, and I concur with him in thinking that this is not correct, at least so far as our Irish greensand is concerned.*

In 1874, a few weeks previous to the meeting of the British Association held in Belfast, I discovered Foraminifera in abundance in soft shaley partings that occurred in the Carboniferous limestone quarries at Castle Espie, and this was the first record of Foraminifera of Carboniferous age having been found in Ireland. I have since found them in Carboniferous limestone from Bundoran, the material having been collected by Mr. Stewart.†

Notwithstanding the many noble bays and loughs which indent our coast, and the fine facility thus afforded for studying our marine zoology, comparatively little has been accomplished by our Irish naturalists so far as the Foraminifera are concerned, the only paper of much value on the subject being one by Dr. Alcock on gatherings taken between tides in Dog's Bay,

* S. A. Stewart. The Greensand and its origin. Hardwick's Science Gossip, Nov. 1875, No. 131.

† For further information on the Carboniferous Foraminifera, see Mon. Carb. and Perm. For. by H. B. Brady, F.R.S., pp. 43 and 157.

Connemara.* In this memoir he enumerates no less than sixty different species. The only other records of importance are in Professor Williamson's monograph of the British Foraminifera, published by the Ray Society, nearly all the Irish material in it having been contributed by Mr. George Hyndman from dredgings taken off the Antrim Coast; and a report read before the British Association, 1857, on dredgings taken in Belfast Lough. From these three sources combined we have sixty-five species, and they comprise all that was known of recent Irish Foraminifera up to 1875. In the autumn of this year a number of Belfast naturalists joined Mr. Thomas Workman in his yacht Denburn for the purpose of dredging Belfast Lough and the waters adjacent, and thus commenced a series of dredging operations which have resulted in adding considerably to our knowledge of the living Foraminifera round our coast. Gatherings have been taken from twenty-nine stations. Six of these were from Strangford Lough, and the remainder from Belfast Lough and the channel outside; four were from between tides, the others from depths varying from four to seventy-two fathoms, the greatest depths attained being in the vicinity of the Maiden Lighthouses. Strangford Lough was dredged by me in company with Mr. S. A. Stewart, the others with Mr. Wm. Swanston, F.G.S., to whose hearty co-operation much of the success attending these excursions was due.† Already one hundred and ten different species and well marked varieties have been found, or about 65 per cent. of our British forms. All of them, with the exception of Lagena striato-punctata,‡ occur in Belfast Lough and the deep water outside, and ninety-seven in Strangford Lough. Many rare forms were met with, as Quinquiloculina pulchella, Lituola globigeriniformis, Lagena hispida, Jeffreysii, trigono-marginata, striato-punctata, oblonga; Polymorphina concava, Operculina ammonoides, Discorbina parisiensis, &c.§ Lagena hispida,

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* Proc. Lit. and Phil. Soc. of Manchester, Vol. IV., No. 15, 1864-5, p. 192.

† I have also examined a number of beach gatherings collected by Mr. Gray.

‡ This species has since been found in Belfast Lough.

§ For a full list of the Species found, see Rep. Belfast Nat. Field Club, Appendix 1876-7.

oblonga, and Discorbina parisiensis being new to our British fauna. Of the Lagenas alone, 22 different forms occurred, these being found in the greatest profusion when the bottom was mud or fine sand. Many of the species were the same as those now found living in the abyssal depths of the ocean, as brought up by the "Challenger" and "Porcupine" explorers, whilst others were of the same species as those found fossil in the chalk and lias; a few even extending as far back as the carboniferous period.

18*th December*, 1877.

ROBERT YOUNG, Esq., in the Chair.

Abstract of Paper read by JOHN H. GREENHILL, Esq., Mus. B., T.C.D., on

PROFESSOR GRAHAM BELL'S "TELEPHONE."

I THINK I am justified in stating that no invention since the introduction of what is known as the ordinary telegraph has created so much interest in scientific and non-scientific circles as the Telephone; and although the reports which have been circulated regarding the effects produced by the instrument, have been greatly exaggerated, yet all must acknowledge that the results of the experiments are of a most marvellous nature. When it is taken into consideration that not only may the words be heard by a listener several miles away from the speaker, but the peculiarities of voice and pronunciation are faithfully reproduced, so that any one with a little practice in the use of the Telephone may easily recognise whether or not it is a friend who is communicating with him, it is enough to account for the astonishment which has been evinced. Further, when it is considered that the construction of the instrument is of so simple a nature, that those possessing slight knowledge of electrical science may construct a pair of Telephones for a few shillings, the simplicity of the parts rather increases than diminishes the wonder with which the instrument is regarded. The exaggerated reports which have preceded the introduction of the Telephone into Europe naturally cause a little disappointment to those who have formed their ideas of the instrument's capabilities by the accounts they have read in some of the newspapers. These accounts owe their origin to the lively imagination of the American reporters. In using the Telephone, it is absolutely necessary that silence should be maintained when listening for the signals, and the instrument should be pressed to the ear, and if possible, the other ear should be closed against external noise, otherwise there will be great difficulty in distinguishing what is said. I think we may consider the Telephone to be in its infancy, and it is therefore only reasonable to expect that an improvement will be made in its construction. The theories involved in the Telephone are more complex than the arrangement of its parts, and in order fully to understand the nature of the instrument, it will be necessary to briefly consider two different branches of science, namely Acoustics and Electricity, combining with the latter, Magnetism.

In treating the first-mentioned of these subjects, we shall merely glance at the production of sound-waves by vibrations, and the reproduction of the latter by the former. Suppose we take a thin piece of steel, say about two feet long, and fasten one end in a vice; then draw the free end aside, and suddenly let it go, the elasticity of the steel will cause it to return, not only to the position from which we disturbed it, but to a considerable distance beyond, and it will move backwards and forwards for a time; each journey, however, being less than the preceding one, until it finally comes to rest. A complete vibration consists of one movement forward and one backward. If a number of these vibrations occur within a short period, a musical sound will be heard, the "pitch" of such sound depending upon the frequency of vibrations. While the spring is oscillating, the loudness of the sound gradually diminishes, although the pitch remains the same. This diminution arises from the gradually decreasing amplitude (or distance travelled by the spring) of each vibration; the time occupied in making each of these journeys, whether great or small, is practically the same, from which arises the constancy of pitch. While the spring moves, it disturbs the air in its immediate vicinity. The molecules of the air are pushed forward and compressed while the spring is advancing, and they return and expand with its opposite movement. This variation in the density of the molecules of the air is the cause of "sound-waves";—their propagation may be illustrated, though imperfectly, by having a number of elastic balls suspended, and in contact with each other. If one of these balls is struck or pushed forward, it will be slightly compressed, and this compound movement is imparted to the others, which in their turn convey still further the disturbing action. While this forward and compressing movement is progressing, the first molecules are returning to their original position, and also expanding, thus being in a condition to undergo a repetition of what had taken place. There is a vast difference in the velocity of the movement between the experimental elastic balls and the molecules of the air, the former only occurring a few times per minute, while the latter may have several thousand changes per second. It is, perhaps, necessary to explain that there is no direct connection between the amplitude of vibration of the disturbing medium and the length of sound-waves. For instance, the reed in the bass of a harmonium may only vibrate through a distance of one or two inches, and yet the "sound-wave" so produced may be several feet in length. It is unnecessary to enumerate the various means by which these waves are produced, as any source of *sound*, must, of necessity, produce the disturbance in the air which constitutes the *waves*. It will be readily understood that the rapid changes in the density, and therefore the varying pressure, of the molecules of the air, will affect various materials, and this is the cause of what may be termed sympathetic vibrations. If, however, any material will produce a musical tone of a certain pitch, its vibrations will occur at a certain velocity, and therefore only sound-waves which impinge or act upon it at a similar velocity with which such material vibrates will have any effect in putting it in sympathetic oscillation. This accounts for the fact of a tuning fork in vibration being able to select from a number of others of various pitches one which will produce the same one as itself, and putting it in a state of agitation, while the others of different pitches (except the octaves) will remain at rest. Any material, without possessing a definite tone itself, may be put into sympathetic vibration by various sounds, but the amplitude of such vibrations will be small compared to the original. Consequently, any person singing or speaking in a room will cause the furniture or even the floor slightly to vibrate with each sound or inflection of his voice. A stretched membrane or metallic diaphragm will vibrate with great susceptibility to various sounds produced in their vicinity. There is a great difference between the sound-waves of a musical note and those of an articulated word. The former are *regular*, while the latter are *irregular* and most erratic. Diagrams of the different sound-waves can be taken by an instrument termed a "Phonautograph," invented by Mons. Leòn Scott. The figure representing a musical tone is a regular wave line, while that of a word has the appearance of irregular heights and hollows.

Amongst the most perfect apparatus for producing sounds, the human voice must take high rank. The organs of speech consist of the chest and lungs, the windpipe, larynx, posterior cavity of the mouth, the nostrils, palate, tongue, and teeth. What is know as "voice" is produced principally in the larynx, although this organ would be useless without the chest and lungs, which act as the wind suppliers. In speaking, the other organs play an important part by regulating or changing the sound which proceeds from the "glottis" or "vocal chords" of the larynx. These "vocal chords" are capable of being put in greater or less tension with great rapidity at the will of the speaker or singer, and thus the pitch of the sound can be suddenly changed. The act of "speaking" is a purely mechanical operation. It consists of stopping, dividing, or otherwise interfering with the sound emitted from the larynx by means of the other organs of speech. To prove this, I shall illustrate the manner in which two familiar words, namely "Mamma" and "Papa" can be produced by extremely simple appliances. These consist of a child's toy trumpet, a piece of flexible tubing of India-rubber, and a pair of bellows. The latter have a small strap of leather, so that they can be worked by the foot. Connecting the trumpet, by means of the tubing, to the bellows, I place my hand on the bell-mouth, and pressing the bellows slightly, the small reed in the trumpet produces a sound like the pronunciation of the letter *m*. Withdrawing a portion of my hand gradually from the bell-mouth, I get the broad vowel sound of *a*. This connected to the first sound gives "Ma" very clearly, and again closing the end of trumpet as before, and repeating the operation, the total word is clearly heard. To make my contrivance pronounce the word "Papa," the trumpet is not interfered with, but the tubing is pinched firmly between the finger and thumb, as near to the trumpet as possible; a pressure of wind is obtained from the bellows, and quickly releasing my pressure on the tubing, but as quickly resuming it, I get the explosive sound of the letter p, and also the short vowel sound, which distinctly pronounces the first syllable of the desired word. I repeat the operation, but allow a little longer duration of the vowel sound, and the word "Papa" is the result.

Turning our attention for a short time to electricity, I shall merely refer to two ways in which it can be produced, these being sufficient for my purpose. If we immerse two different kinds of metal in an acid solution, one of the metals being more easily oxydised than the other, we shall have a simple galvanic battery, capable of producing electricity when the two plates are inclined so that they touch each other at their upper edges. A simple way of making "metallic contact" between these plates is by attaching a wire to one, and allowing the wire to touch the other. So long as there is no contact, there is no development of the electrical current, but the moment the wire unites the two plates, the current passes along the wire, and continues doing so until the contact ceases, or until the metal is consumed or otherwise affected by the solution. Now if a portion of this wire is wrapped round a piece of soft iron, in such a manner that each turn of the helix or coil does not touch its neighbour or the soft iron core, (this result being obtained by first *insulating* or covering the wire with silk or cotton) while the current of electricity is passing along the wire, the iron core becomes magnetised, and capable of attracting and holding other pieces of iron or steel. When the current is stopped by disconnecting the wire from one or both of the metals in the acid solution, the iron core loses its magnetic properties. If a piece of hardened steel is substituted for the soft iron, the steel will be made magnetic, but it will retain some of its attractive power for an indefinite period after the current of electricity ceases to pass; and if this steel magnet is suspended by a silk thread, the ends of it (the magnet) will arrange themselves nearly due north and south. The steel will have its ends of north and south "polarity." If the steel is again inserted in the helix or coil of wire, and the ends of the wire changed from the one metal to the other, the current of electricity will pass along the wire, but in the opposite direction, and the magnet will at first be gradually weakened until its attractive powers are lost; but if the current is still allowed to flow, the steel will again become magnetic, but with a different polarity; that is, if again suspended by the silk fibre, the end which formerly swung round to the *north* will now point towards the *south*. If the insulated wire is withdrawn from contact with the metal plates, and its ends attached to an instrument called a galvanometer, which indicates the passage of electrical currents, and if the magnet is quickly inserted in the helix or coil, the needle of the galvanometer will suddenly be deflected, but will swing again to its original position. If the magnet is withdrawn from the coil, the needle will again be disturbed, but it will move in the opposite direction to the first. The insertion and withdrawal of the magnet cause currents of electricity to pass along the wire. This is termed *inducing* electricity by magnetism. By this, it will be seen that electricity will produce magnetism, and magnetism will also induce electricity; but there is a marked difference between the two actions, namely, that the magnetism obtained by electricity will remain in iron so long as the current flows round it, and even in steel after the current ceases; but the electricity induced by magnetism is only of temporary duration, even though the magnet either remains in or out of the helix. Of course, it may be said that this difference is more apparent than real, as both depend upon a certain movement for their existence, namely the *flow* of the current and *movement* of the magnet.

Electricity can be induced in a coil of wire in which a magnet has been inserted, by the approach or withdrawal of a piece of iron to or from the end of the magnet. This arises from what is termed a disturbance in the "magnetic field" by the movement of the iron. An important fact to remember in connection with this last mentioned result, is, that the piece of iron need not *touch* the magnet on its approach, but may be moved backwards and forwards at variable distances; the strength of the *induced current of electricity* will always be in a certain proportion to the proximity or distance of the iron from the magnet. By varying this distance an *undulating* current is obtained. I have not entered minutely into the theories of the results obtained, as it is unnecessary to do so here, my object being to explain the construction of the Telephone, and the manner in which it operates. Before leaving the subject of induced currents, it is advisable to mention one important feature connected therewith, as it has proved to be a source of annoyance in the practical use of the Telephone. If two wires are supported by the same posts, and are parallel to each other for some distance, intermittent currents passing along the one wire will induce intermittent currents on the other, and Telephones, being exceedingly sensitive to all currents of electricity, will therefore record signals not intended for the wire with which they are connected.

The instrument consists of a round bar of steel, about five inches long, and half-an-inch in diameter, which has been magnetized. One end of the steel is slightly reduced in size, and upon this is placed a small bobbin, having about fifty yards of very fine insulated copper wire (No. 36 or 40 wire gauge will answer). The ends of the wire are attached to terminal binding screws, and the magnet and bobbin of wire are enclosed in a wooden case. Opposite the end of the magnet, and at a distance of about one-twentieth of an inch, is placed a circular disc of very thin iron, which is held in position by being "clamped" at the periphery between the wooden case and the mouthpiece. The latter is a circular piece of wood, with a cavity into which the lips of the speaker have space to move. In the centre of the cavity, and therefore opposite the thin disc of iron, there is a small hole about half-an-inch in diameter, through which the sound waves pass, and impinge on the disc or diaphragm. There is a space left between the wooden mouthpiece and the diaphragm, which acts as a resonant chamber, and allows the metal freedom to vibrate. A small regulating screw is generally inserted at the opposite end of the magnet, to vary the distance between the latter and the diaphragm.

A modified Telephone consists of a horse-shoe magnet with a bobbin of wire on each extremity, the other parts being similar to that already explained, except that the casing is different. The manner in which the instrument operates is, that when words are spoken into the mouthpiece, certain sound-waves of varying intensity and duration impinge upon the diaphragm or disc of iron, which rapidly vibrates. The diaphragm, when vibrating, approaches or recedes from the magnet in a manner identical with the character of the sound-waves. These vibrations *induce* corresponding currents of electricity in the wire coiled upon the bobbin, which pass to the terminal binding-screws, and thence by the wires which connect the transmitting to the receiving telephone, the latter, perhaps, being many miles distant. The current proceeds along the insulated wire of the receiving instrument, which is identical in construction to that explained, and passing round the magnet, it either increases or diminishes the attractive properties of the latter, according to which way the current passes; but this is immaterial, as, if the magnet is made more powerful, it is instantly made correspondingly weaker, so that the diaphragm is drawn or released by the variation in the strength of the magnet, and it vibrates in a similar manner to the diaphragm of the transmitting instrument; and thus the identical words, peculiarities of pronunciation, and "timbre" of the speaker's voice are reproduced practically at the same instant by the receiving Telephone.

I have endeavoured to explain as briefly and yet as thoroughly as space and time would permit, the theory and construction of this marvellous invention, and I shall now conclude my paper with a short reference to other instruments which have been termed "Telephones," and to their inventors.

In the year 1837, Page, an American physicist, discovered that the rapid magnetizing and de-magnetizing of iron bars, produced certain sounds, which he termed "Galvanic music." De la Rive of Geneva, in 1843, increased these musical effects by passing wires through bobbins on which was coiled some insulated wire, along which an intermittent current of electricity was made to pass. In 1861, Philip Reiss of Friedrichsdorf invented a telephone which reproduced music at a distance. He utilized the discovery of Page, and caused a rapid "make and break" in a galvanic circuit by means of a vibrating disc or diaphragm. This was useful for reproducing musical tones, but failed with articulated words, as instead of his instruments being capable of producing currents of varying intensity, necessary for the production of *words*, they only caused intermittent voltaic or battery currents to pass along the wire.

Mr. Elisha Gray, of Chicago, is the inventor of a species of musical telegraph. He makes use of a vibrating reed between two pairs of electro-magnets, and if the number of reeds is increased, and each tuned to a different note of the diatonic or chromatic scales in music, it is expected that Mr. Gray's invention will facilitate the transmission of several distinct messages at the same time upon one wire.

Mr. Cromwell Varley, some years ago, constructed an instrument with tuning forks for the transmission of musical signals; these forks were connected with a battery and line wire, a similar arrangement being at the distant station. When any particular fork was sounded, it caused a rapid "make and break" in the current of electricity in exact accordance with the number of vibrations; and this action being received at the distant station only affected the tuning fork whose vibrations were isochronous with those of the transmitter, thus producing the same pitch of note. When another fork was caused to vibrate, it selected from those at the other station the one in unison, and thus music could be reproduced by means of electricity. Varley's musical Telephone thus depends upon sympathetic vibrations arising from intermittent currents of electricity.

Mr. Edison, the inventor of the Phonograph, has been successful in reproducing words by *voltaic*, or *battery*, currents of electricity, while Professor Dolbear, a distinguished American, claims to have invented articulating Telephones. Professor Bell, whose name is now inseparably associated with the Telephone, has been working at it with indefatigable zeal since the year 1872. It is stated that he was first led to think of it by endeavouring to teach the deaf and dumb patients of one of the asylums in America the nature of musical and articulate sounds. For this purpose he used Leòn Scott's Phonautograph, to which I have previously referred. By degrees, and after numerous failures, his efforts in the construction of a "speaking telegraph" were crowned with success; and although further improvements in his invention are not only possible but probable, few will decline to acknowledge that his discovery entitles him to the highest position amongst the inventors of the present time.

8th January, 1878.

ROBERT YOUNG, Esq., in the Chair.

A Paper was read by THOMAS WORKMAN, Esq., on

SPIDERS.

SPIDERS are not generally considered pleasing, or a subject of much interest; and we, for the most part, look on them with aversion and disgust for what we are pleased to call their ugly looks and cruel habits.

I have no doubt that the heart-rending tragedy, learnt in our childhood, at our mother's knee, commencing with: "Will you walk into my parlour, said the spider to the fly"; and the terrible state of uncertainty in which the listener is left, has implanted in most of our minds a deep-rooted dislike to the whole tribe. I am sure, therefore, you will be pleased to consider me a mild enthusiast, if not worse, when I state that spiders are not only one of the most interesting and useful of all the orders of the Animal Kingdom, but for beauty of colouring will vie with the moths and the brightly coloured beetles: I will not strain your belief so far as to include those most marvellous creatures of nature's adorning, the butterflies.

On account of the prejudice mentioned, few in this country have given any attention to this branch of natural history; and nearly all we know of their habits and economy we owe to the observation of Continental naturalists.

Dr. Martin Lister's "Tractatus de Araneis," published exactly 200 years ago, has formed the basis of every subsequent attempt to classify spiders.

Since the time of this celebrated Englishman, until very lately, this subject was quite neglected here. About 40 years ago Mr. John Blackwall gave his attention to our native Araneidea, and after many years' patient research, brought out, under the auspices of the Ray Society, in two vols, one of the finest works on any department of our British fauna. I cannot but add a tribute of respect to Dr. Robert Templeton, one of the original members of the Natural History and Philosophical Society, to whose researches Mr. Blackwall owed much information, and to whom all that we know of Irish spiders is due.

On the subject of spiders, we have no work in the English language that treats on the whole order; and on foreign spiders, one can merely get the names and characteristics scattered through different scientific works, so that to know much about spiders, one has to resort to the works of Continental observers; therefore, the pursuit of knowledge in this department has to me been one of some difficulty, seeing I know but little of French and less of German. I hope, in the sketch of such an extensive subject, you will excuse a want of regularity in my dealing with it, as it is utterly impossible to consider the subject of spiders, and treat it in the method it should be done, in the time at my disposal.

Spiders, or Arachnidans, were long confounded with insects, and described as such even by entomologists; but are distinguished by characteristics that unmistakeably separate them.

In Insects, the external skeleton presents three principal divisions, the head, the thorax, and the abdomen; but in the spider tribes, the blood-thirsty destroyers of the insect world, the separation of the head from the thorax, which by increasing the flexibility necessarily diminishes the strength of the skeleton, is no longer admissible; and the process of concentration being carried a step further, the head and the thorax coalesce, leaving only two divisions of the body recognisable externally, namely, the cephalo-thorax and the abdomen.

Insects, in their mature forms, are found to be invariably furnished with only six legs; but in the adult arachnidans eight of these limbs are developed.

Arthropoda, or articulated animals, the sub-kingdom in which spiders are placed, are distinguished by the possession of jointed appendages, articulated to the body.

Arthropoda are divided into four classes:—Insecta, Arachnida, Myriopoda, and Crustacea. The Rev. O. P. Cambridge, in his recent article on Arachnida in the new edition of the Encyclopedia Britannica, has suggested that, by placing the Myriopoda above the Crustacea, we seem to get an ascending series in respect to the number of the legs. In the Insecta, 6, always attached to the thoracic segments; in the Arachnida, 8, almost always attached to the thoracic segments; in the Crustacea, 8 or 10, and upwards, frequently attached to the abdominal as well as the thoracic segments; in the Myriapoda, 24 or more, always attached to the abdomen as well as other segments.

The class Arachnida has been divided into 7 orders:—Acaridea, Phycnogonidea, Phalangidea, Solpugidea, Scorpionidea, Thelyphonidea, Araneidea.

The Acaridea have the head, thorax, and abdomen united, and are represented by the cheese mites, and those small red mites one finds swimming in fresh water; while the Phycnogonidea, curious creatures, found only in the sea amongst wreck, &c., are by some placed among the Crustacea. The Phalangidea are often mistaken for spiders. Our native species are called Harvest-men—I cannot say for what reason, except that at that season they are most abundant. Though there is not much known about them, they are believed not to live over the winter, and are carnivorous. They can easily be distinguished from spiders by the cephalo-thorax and abdomen coalescing, having no palpi nor spinners, and having the abdomen segmented; they have but two eyes, placed together, and in most native species surmounted with a curious comb. Their legs are of enormous length. The Solpugidea are curious, but little known animals, found in tropical countries. The Scorpionidea are well-known in appearance, but have not been much observed by naturalists. In the Thelyphonidea we have a much nearer appearance to the true spiders; but they can be easily distinguished from the latter by their having the abdomen segmented, and possessing no spinners.

The nervous system of insects consists of long cords of nervous matter, which is thickened in different parts of its length; it is from these masses, called ganglia, that filaments of nervous matter are given off to the eyes, stomach, &c.

We find in spiders a higher development of the nervous system. Instead of numerous ganglia along the central chain, we find but two nervous masses occupying a large part of the cephalo-thorax, from which nervous filaments proceed to the eyes, the legs, and the parts of the abdomen.

The circulation of the blood in spiders shows also a remarkable degree of perfection; and if compared with insects, we find a notable difference.

As amongst other invertebrates, their blood is a colourless, somewhat whitish coaguable liquid, holding in suspension egg-shaped corpuscles.

The heart is placed on the dorsal part of the abdomen; it is a tube thicker at the front than behind, and enveloped in a thin fibrous covering or pericardium. This tubular heart is divided into four chambers, which are indicated on the exterior by four contractions, and communicate with the interior of the pericardium by means of little orifices called auriculo-ventricoles; these openings are furnished in the interior with folded membrane disposed in the form of valves, which permit the entrance of the blood, but prevent it going out during the contraction. When the heart contracts, it forces the blood into the artery which opens at the forward part of the heart. This vessel is called the aorta, and traverses the pedicle or stalk joining the abdomen and cephalo-thorax. On its entrance into the cephalo-thorax, it divides into three pairs of arteries; the upper proceeds along the back, and furnishes arterioles to the eyes, faces, and mouth; the second is destined to nourish the organs lying upon the stomach, while the third sinks under the stomach, and carries into each limb the arteries which are prolonged to their extremity. These three pairs of arteries reunite, surrounding the brain. At that part they join an important canal, which, directed backwards, passes under the ganglia and penetrates the abdomen, where it continues back right to the spinners, along the nervous chain. This returning artery is called the abdominal artery, and furnishes numberless branches to the different organs which it passes in its course.

The most remarkable structures in spiders are the spinners, by which these little animals are enabled to construct their webs, or nets and habitations. The spinners are situated at the extremity of the abdomen, and present themselves under three forms. The first are six in number, all equal, long and truncate, placed in a little bundle; the second are generally four in number, the inferior spinners short, while the superior are long, resembling palpi on account of their articulation; the third, situated on the ventral side of the abdomen, are four or six, equal in length, short, and inclined towards one another, forming a little rose-shaped tubercule. The use of the long spinners, or mammulae, seems to be to bind down with transverse lines, distributed by means of an extensive lateral motion, the threads emitted from the inferior mammulae, by which process a compact tissue is speedily fabricated, somewhat resembling the method by which telegraph cables are bound round.

Spiders are oviparous, and when about to deposit their eggs, usually spin silken cocoons for their reception, which exhibit much diversity of form, colour, and consistency, and are placed in various situations, according to the economy of the species by which they are fabricated. Many spiders abandon their cocoons as soon as they are completed; others manifest great attachment to them, watching over them with the utmost solicitude; and some connect them with the spinners by silken lines, or, grasping them with the falces and palpi, transport them wherever they move. In numerous instances, the eggs are agglutinated together into a compact mass; in others they are united by filaments of silk; and not unfrequently they are entirely free or unconnected. Their figure is either spherical or somewhat elliptical, and their predominant colours are yellowish white, yellow, brown, and pink. On coming out of the egg, the young spiders generally disperse and look after themselves; but some species continue to live together for a considerable time, and in many instances are supplied with sustenance by the mother. I have seen a specimen of Trochosa picta, a common species, on the sand hills near the Giants' Causeway, covered with its young, clinging to the cephalo-thorax and abdomen, giving it a very strange appearance.

Before they arrive at maturity, spiders change their integument several times. The manner in which these moults are effected may be illustrated by describing the proceedings of an individual of the species Epëira calophylla.

Preparatory to casting its integument, Mr. Blackwall says, this spider spins some strong lines in the vicinity of its snare, from which it suspends itself by the feet, and by a filament proceeding from the spinners. After remaining for a short time in this situation, the coriaceous covering of the cephalo-thorax gives way laterally, disuniting at the insertion of the legs and falces; the line of separation pursues the same direction till it extends to the abdomen, which is next disengaged; the extrication of the legs being the last and greatest difficulty the spider has to overcome. As the suspensory thread connected with the spinners of the cast-off skin is considerably shorter than the legs, and does not undergo any sensible alteration in length, the abdomen, during the casting-off process, becomes gradually deflected from its original horizontal direction, till it assumes a vertical position nearly at right angles with the cephalo-thorax. By this change of posture, attended with numerous contortions of the body, and alternate contractions and extensions of the limbs, the spider is ultimately enabled to accomplish its purpose. When it has completely disengaged itself from the old skin, it remains for a short time in a state of great exhaustion, suspended solely by a thread from the spinners connected with the interior of the abdominal portion of the cast skin, which is much corrugated. After reposing a little, the spider further attaches itself to the suspensory lines by the claws of the feet, and when its strength is sufficiently restored, and its limbs have acquired the requisite degree of firmness, it ascends its filaments, and seeks its retreat. It has been found that the number of times spiders change their skin before becoming adult is not uniformly the same as regards every species, Epëira calophylla having been observed to moult five times, and Tegenaria civilis nine times, from the period of their extrication from the egg till they arrive at maturity.

Like the Crustacea, spiders possess the property of reproducing such limbs as have been detached or mutilated ; and this curious physiological phenomenon is intimately connected with the renovation of the integument; for legs, palpi, and spinners which have been amputated, are observed to be restored, and afterwards to have their dimensions enlarged, at the period of moulting only.

Little is known about the age of spiders, but specimens of Tegenaria civilis and Segestria senoculata have lived four years.

It seems strange that, though the number, disposition, and relative size of the eyes of spiders constitute important elements in their classification, no one seems to have given much attention to the anomalies of structure and position in them. If we consider that though there are nearly 200,000 species of the class Insecta, with its varied forms of butterflies, moths, beetles, &c., and the closely connected orders of Crustacea and Myriapoda, it is strange we should have nothing like it; for as far as I know, none of the Insecta, Crustacea, or Myriapoda have more than two eyes; which in the class Insecta are placed, I think, invariably on the fore part of the head; while amongst the spiders we find the eyes most variable; some species have the eyes placed in a small group on the fore-part of the cephalo-thorax, as the Territalariae or Mygale; in others I may say scattered over the cephalo-thorax, as the Saltacidae; while others have them raised on posts above the body as Walckenaeriae; while again, some have no eyes whatever, such as the Anthrobia and Hadites.

It has occurred to me that the variability may be accounted for in this manner;—that while insects only use their eyes for observing distant objects in a general way, and for close observation depend on their antennae to feel the object, spiders are more dependent on their eyes, as the palpi do not seem to have the delicate feeling power of the insect's antennae. For instance, in the Salticus the eyes are placed two in front, and the others along the side of the cephalo-thorax; while in the

Territelariae they form a small group in front. Now the Salticus lives under stones, and does not make a web, but has great power of jumping about, from whence its name; it needs, therefore, to see sideways as well as before, to enable it to catch its prey and preserve itself from danger; the Territelariae, or trap door spiders, would be incommoded by eyes on the side, as they live mostly in their curious nests in the ground, and catch their prey just at their doors, rarely venturing from home.

Many spiders can run on the surface of water with great facility, and even remain below for some time, carrying down with them a small quantity of air confined among the hairs with which they are clothed, as Notanecta or Boatflies and Water-beetles do; but there is only one species, Argyroneta aquatica, which constantly lives in the water. This very interesting spider is nowhere very common; but Mr. Blackwall, on the authority of Dr. Templeton, says it is to be found in the neighbourhood of Lurgan. It weaves for itself a very curious little bell-shaped dwelling at the bottom of the water, which it fills with air that it brings down from the surface amongst the hairs with which its body is thickly covered, a process very closely resembling that by which the earliest diving bells were supplied with air.

Simon, in his natural history of spiders, a French work, gives the following account of its procedure. The Argyroneta constructs in ponds a large dome of silk, which she carefully fills with air. This is her method of constructing the edifice;—first of all she mounts to the surface of the water; keeping her head down, she permits the extremity of the abdomen to come to the surface, dilates her spinners, and dives with rapidity. During this operation she gathers a little bubble of air, which is found attached to the spinners, independent of the silvery bed of air which is collected on the abdomen. She next swims towards the stalk of the plant where she desires to place her nest, and detaches the little bubble of air which adheres to the stalk. Mounting immediately to the surface, she collects another bubble, with which she returns to join it to the first. She continues this until the balloon of air has attained a size a little greater than that of a nut. She afterwards envelopes it in threads, which form a sort of net covering resembling that of the Clubiona, then she surrounds it with a brilliant half-liquid mortar, which appears to be nothing else than the silky matter in dissolution, which she kneads with her feet, and unites with much art.

The form of the bell or cell is oval, more or less rounded. The entrance is at the lower part; it is a slit, the elastic sides of which the spider dilates for entering or going out of her house. From the cell radiate numerous threads, which are taken and attached to divers surrounding objects, the stones at the bottom, the stalks of aquatic plants, &c. These threads serve to maintain the nest at the desired level, for the lightness of the air tends to make it remount to the surface. The threads are also stretched as snares for aquatic insects, such as the water-beetles, the small crustacea, &c , on which the Argyroneta lives.

Sometimes she attacks and eats her prey on the spot, sometimes she paralyses it with her poison, and drags it into her nest; at times she contents herself by killing and leaving it on the threads as a reserve. She also feeds on terrestrial insects as well as aquatic; when the supply of the latter fails, she seizes flies which have tumbled by accident into the water, or she comes to the borders of the ponds to pursue the terrestrial insects, but she always drags them to the bottom of the water before eating them.

Mr. Blackwall speaks of a specimen of Argyroneta aquatica which was kept for some time in a tumbler of water, where it built its nest, and remained for a time in a state of hybernation; but was unfortunately drowned by a too curious gentleman turning up the tumbler so far that the air escaped from underneath the silken dome.

There seems to me some mistake in both Monsieur Simon and Mr. Blackwall's statements regarding this spider, for two reasons: First, it is now well-known by all aquarium keepers, that water tends to absorb air, and therefore would soon replace the air in the web with water, thus drowning the animal if in a state of hybernation; and second, as our friend Dr.

Macormac could easily demonstrate to us, the Argyroneta would soon asphyxiate itself, as is too often done by many of its home-loving representatives among bipeds, by using up all the oxygen and giving off carbonic acid gas. I am inclined to believe that this curious little creature makes its nest always on some aquatic leaf; and leaves, as we all know, absorb carbonic acid gas and give off oxygen, so always keeping the spider well supplied with the air necessary to preserve it in health.

I had intended to give in this paper some account of the many sorts of spiders' webs and nests, and make a few remarks on our Irish species, but I found that time would not permit; I trust, however, that what I have said may have been interesting to you all, and if in any I should raise a desire to know more of the wondrous works of nature as exemplified in these little creatures, my labour will, indeed, not be lost, for

> "Each shell, each crawling insect holds a rank
> Important in the plan of him who framed
> This scale of beings: holds a rank which lost,
> Would break the chain, and leave behind a gap
> Which nature's self would rue."—*Stillingfleet.*

22nd January, 1878.

ROBERT YOUNG, Esq., in the Chair.

Professor EVERETT, M.A , D.C.L., read a Paper on

ATMOSPHERIC ELECTRICITY.

IN discussions relating to the electrical condition of the air at a specified point, three things must be carefully distinguished ;—first, the electrical *density* at the point ; secondly, the electrical *force* at the point ; and thirdly, the electrical *potential* at the point.

The electrical density is computed by considering the quantity of electricity contained within a very small space, of which the point is the centre, and dividing this quantity by the volume of the said space.

The force is computed by considering the force which would be exerted upon a small body charged with a small quantity of electricity and placed at the point, and dividing this force by the quantity of electricity with which the small body was charged.

The potential can be computed by considering the work which would be done by electrical attractions and repulsions upon a small body with a small charge of positive electricity, when the body is supposed to move from the point in question to the earth. This work divided by the charge of the body is the potential at the point.

There is a close relation between potential and force. When the potential is uniform throughout any portion of space, there is no electrical force in this region ; and when the potential is not uniform, the force along any line is equal to the rate at which the potential varies as we travel along the line.

Observations of atmospheric electricity usually consist in a determination of the difference of potential between the earth and a certain point or points in the air. It is almost always found in fine weather that the potential becomes more highly positive as we proceed further from the earth. The electrical force in the air near the earth is therefore directed downwards; and its amount at any time can be shown by a well-known theorem in "attraction" to be proportional to the quantity of electricity beneath the point. In fact, if we erect an imaginary vertical cylinder of unit base, standing upon the earth, and reaching up to the point, the quantity of electricity residing on the base of this cylinder, together with the quantity within the cylinder, is equal to the force at the point divided by 4π. If the force at the point were directed upwards, this quantity of electricity would be positive; as the force is, in fact, directed downwards, the quantity of electricity is negative. If we ascend so high in the air as to come to a point where there is no electrical force either upwards or downwards, we shall have exactly as much positive as negative electricity below us.

The determination of the electrical density in the air is a matter of much greater difficulty than the determination of electrical potential. Sir Wm. Thomson has made a few observations bearing on this point, and has found that the electric charge of the air at Glasgow, up to the height of several feet, at least, is always negative.

I shall now proceed to a description of some modes of observing the electrical potential at a point in the air. Two pieces of apparatus are necessary. One serves the purpose of bringing an insulated conductor to the same potential as the given point in the air; the other serves to measure the potential to which the conductor is thus brought. The former piece of apparatus is called a *collector*, the latter an *electrometer*.

The most efficient form of collector consists of an insulated conductor which is continually throwing off matter from a projecting portion of its surface. Then, if the potential of the conductor be at any time different from that of the air immediately contiguous to that part of its surface, each portion of matter that passes off will carry with it electricity either positive or negative, and will leave the conductor more nearly at the potential of the air than it was before. For example, if the conductor is at a lower potential than the air, negative electricity is carried off by the matter which is passing away, and the potential of the conductor rises.

Sir Wm. Thomson's water-dropping collector is a copper vessel capable of holding some gallons of water, and furnished with a brass pipe several feet in length, through which this water is discharged in a fine stream, which breaks into drops soon after leaving the nozzle. The vessel is supported on a strong glass stem, surrounded by an artificially dried atmosphere. The "insulated conductor" consists of the vessel and its contents, together with the issuing stream of water, as far as the point where it breaks into drops. The point at which the stream breaks into drops is accordingly the point whose potential the conductor is made to assume, by the convective process above described.

A flame, or a stream of smoke and hot gas from a smouldering match, answers the same end as this stream of water. Hot gas is a conductor; cold gas is an insulator. The hot gas is accordingly in conducting communication with the flame or match, and the potential obtained is that of the boundary between the hot and cold portions.

For out-of-door observation with a portable apparatus, Sir Wm. Thomson recommends matches consisting of a small roll of blotting paper impregnated with nitrate of lead. In my own observations of atmospheric electricity in Nova Scotia, I employed these matches instead of the stream of water in winter, on account of the trouble caused by the freezing of the water, and I latterly used them in the summer also. The match was stuck on the end of the pipe intended for the discharge of the water, and I found by repeated comparison that there was no difference between the results obtained by the two methods, except that the water-stream produced the desired effect more quickly than the match. This difference in quickness was especially marked in calm weather. The discharging pipe projected from an upstair window into the open air to a distance of $3\frac{1}{2}$ feet, and I was able to make the distance less by removing some of the points of which the pipe consisted,—a change which had the effect of weakening the observed potential in a ratio which was found by numerous trials to be constant, and to be about 3 : 1. Such weakening was necessary on some occasions, in order to bring the potential within the range of my electrometer, and it was of course allowed for in the final reductions.

The difference of potential between the earth and a fixed point a few feet distant from it, is proportional to the electrical force in the intervening space, and this again is proportional to the density of the charge on the earth's surface. Results comparable with those found by the direct observation of potential will therefore be obtained by observing the charge which resides on a given portion of the earth's surface, or on the surface of a conductor connected with it and in a given position. This is the principle of the method employed by Peltier, Dellmann, and Quetelet. A metallic ball was carried into a given position, on the roof of an observatory or in some other place with a free exposure, and, after being connected with the earth by touching it with the finger, was insulated, carried indoors, and tested. The necessity of testing it indoors arises from the fact, that the interior of a house or of any other hollow conductor, is exempt from all inductive action due to external electricity,—an exemption which cannot be secured elsewhere. The charge which the ball, thus tested, is found to have acquired, is clearly proportional to the density of the charge on the earth's surface at the moment when the earth-connection was made by touching the ball with the finger.

Some observers have employed pointed conductors for collecting atmospheric electricity, but this method of observation can only give very rough and uncertain results. The tendency of a point is to reduce the conductor to which it belongs to the potential of the air at the point; but a sensible difference of potentials may remain, and this difference will be greater or less according to the sharpness of the point, and perhaps according to other variable conditions.

Some observers have shot up into the air an arrow attached to a conducting thread fastened at its lower end to a piece of metal resting on the top of the electrometer; so that at the moment when the arrow has attained a height equal to the length of the string, it jerks the piece of metal off the electrometer. The effect thus obtained is a direct measure of the difference of potential between two different heights in the air, corresponding to the positions of the two ends of the thread at the moment when the piece of metal is jerked off. If the upper end is at higher potential than the lower end, negative electricity will be attracted along the thread to the upper end, and positive to the lower, so that the electrometer will give a positive indication. So much for the "collector."

We now come to the other essential portion of the observing apparatus,—the "electrometer" or instrument for measuring the potential which the collector has acquired. All the best forms are inventions of Sir Wm. Thomson, and are described in his "Report on Electrometers" in the British Association Report for 1867. More popular accounts are given in my edition of Deschanel, and also in a sixpenny pamphlet published by Macmillan, containing two lectures by Mr. J. T. Bottomley, delivered in connection with the Loan Exhibition at South Kensington. I shall confine my remarks to points bearing on the suitability of some of these instruments for the observation of atmospheric electricity.

The "quadrant" electrometer, which is the best known, and is largely used commercially in the testing of telegraphic cables, gives its indications by the angular deflection of a mirror, which throws a reflected image on a divided scale. By substituting for this scale a sheet of sensitized paper gradually moved in the vertical direction by clockwork, a continuous photographic record can be obtained. The deflections of the image from the zero point are sensibly proportional to the potential of the conductor tested, so long as the Leyden jar which forms part of the instrument is kept at one constant charge. A little leakage is inevitable, but the loss in a day is not considerable if the instrument is in perfect order. Moreover, the instrument contains a replenisher, by means of which small additions can be gradually made to the charge of the jar, whenever they are shown to be necessary by the gauge which is attached for this purpose.

Photographic records of atmospheric electricity were taken in this way at Kew Observatory for two or three years ending in 1864, under the direction of Dr. Balfour Stewart, and have lately been recommenced under the present management. An attempt was also made about 1864 to employ the same form of recording apparatus at Lisbon Observatory under the direction of Senhor Capello; but on account of the difficulty experienced in using it, a simpler and rougher instrument on the same general plan was substituted. This is not the only quarter from which such failures have been reported; and in order to prevent them, it is very desirable that the observer who is to use the quadrant electrometer should receive personal instruction in its management,—a process which, in order to be efficient, would probably occupy some days.

I am happy to be able to report that preparations are now being made, under the orders of Colonel Crossman, Inspector of Submarine Defences, and on the suggestion of my friend, Captain R. G. Scott of Chatham (son of Dr. Scott, of the Methodist College, Belfast) to establish this method of observing atmospheric electricity at several stations under the charge of officers of the Royal Engineers.*

The portable electrometer is a much handier instrument, thoroughly suitable for carrying about; and its indications, though not near so delicate as those of the quadrant electrometer, are delicate enough for ordinary observations of atmospheric electricity. Its chief defect is that it is not suitable for following rapid and large changes of electrical potential, being manipulated by means of a slow-motion screw, which requires a large

* Captain Scott's lamented death has delayed the execution of this project; but it will probably be carried out before long.

number of turns when a large change occurs in the potential to be observed.

The instrument employed in my own observations in Nova Scotia, was the "cage" electrometer: an instrument which, though it has dropped out of use in recent years, possesses some advantages as an instrument for eye observation. It is well adapted for following rapid and large changes, and is less fatiguing to the eye than either of the other instruments. It has the disadvantage that a little more trouble is required in reducing its indications to proportional measure, inasmuch as the square roots of the observed numbers must be employed instead of the numbers themselves; but this involves no serious labour when a suitable table of square roots is used.

My observations extended over a continuous period of two years, commencing in 1862 and ending in 1864. Accounts of them are given in the Proceedings of the Royal Society, for June 18th, 1863, and January 12th, 1865; and in a Paper in the Philosophical Transactions, for 1868; this last paper containing also my reductions of the photographic curves of atmospheric electricity obtained at Kew.

One remark must be made before leaving the subject of apparatus. The range of potential is so much greater in stormy than in fine weather, that one and the same apparatus cannot profitably be employed for both. The Kew apparatus often failed to give a record in stormy weather. The Lisbon apparatus, on the other hand, gives curves which are hardly distinguishable from straight lines on some occasions in fine weather. In order to obtain a complete record, it seems necessary either to employ two electrometers, one delicate and the other coarse, or else to observe the potential at two different points in the air, one of them much nearer to the earth than the other. In my own observations, both these methods of meeting the difficulty were employed, sometimes separately and sometimes in conjunction, and even the two combined were barely found sufficient.

Now as to the results obtained:—

I. As regards variation of potential according to the state of the weather, I shall employ my own observations, which, for the reason above stated, are specially fitted to throw light on this point. Employing an arbitrary unit of potential, such that the average fine weather potential was + 4, the potential was seldom so weak as 1.0, though on rare occasions it was for a few minutes as weak as 0.1.

In wet weather, especially with sudden heavy showers, it was often as strong as ± 20 to ± 30; with snow, the average strength was about the same as with heavy rain, but was less variable, and almost always positive. Occasionally, with high wind accompanying snow, during very severe frost, it was from + 80 to + 100, or even higher. In fog it was always positive, and averaged about + 10. In thunderstorms, it frequently exceeded ± 100, and on a few occasions exceeded − 200. There was usually a great predominance of negative electricity during thunderstorms. Change of sign was a frequent accompaniment of a flash of lightning, or of a sudden heavy downpour of rain.

There is no other meteorological element, except perhaps wind, that can compare with electrical potential for the extent and suddenness of its variations. Even in fine weather, observations extending over two or three minutes usually show a difference of at least 20 per cent. between the highest and the lowest potentials observed. In changeable and stormy weather the fluctuations are much greater; and on some rare occasions, with no assignable external cause, and notwithstanding the mitigating action of the collector, which eases off all sudden changes, the needle of the electrometer swings from side to side with a violent trembling, like that of a magnetic needle in a strong field.

II. As regards the variation according to the season of the year, I shall base my remarks not only on my own observations and on the Kew curves, but also on the observations of Dellmann, taken at Kreuznach with apparatus invented by himself and described in the Philosophical Magazine for June, 1858, and on Quetelet's observations at Brussels, taken with Peltier's apparatus and described in Quetelet's volume, *Sur le climat de la Belgique*, published in 1849. The observations at all these places concur in showing that the average strength of potential is greater in winter than in summer; but the months of maximum and minimum appear to differ considerably at different places. The chief maximum occurs in one of the winter months, varying (at different places) from the beginning to the end of winter. The chief minimum occurs everywhere in May or June. The average potential in the strongest month is about double of that in the weakest.

III. As regards the variation depending on the hour of the day, the Kew observations, being continuous, are especially to be relied on. They show a double maximum in the twenty-four hours, the hours varying somewhat according to the time of year. In July the hours of maximum are 8 a.m. and 10 p.m., in spring and autumn about 9 a.m. and 9 p.m., and in January about 10 a.m. and 7 p.m.

A few observations of atmospheric electricity were taken in the recent Arctic expedition, by Captain Parr, of the Alert. They suffice to show that the general features of atmospheric electricity were the same at the winter quarters of the Alert as they are in these temperate regions; but the instrument was unfortunately broken when only a few weeks' observations had been taken. Much trouble was caused by the insulating properties of the ice. As long as the frost was only moderately severe, it was found that the ice could be used to give earth-connection in the observation of atmospheric potential, but not in charging the Leyden jar which forms part of the electrometer. As the cold increased, the ice became too bad a conductor even for the former purpose; and it was in making an earth-connection with the ship's cable to take the place of the ice connection, that the accident occurred which put an end to the observations. This fact of the greatly increased insulating power of ice at low temperatures has been independently established by experiments recently conducted by our townsman, Professor John Perry, in conjunction with his colleague Professor Ayrton, at the Imperial College of Engineering in Yeddo, Japan.

The investigations above described relate to the *potential* at a point in the air. I shall now give a brief summary of observations taken about 1860 or 1861 by Sir Wm. Thomson on the electric *charge* of the air. The potential observed at a point of the air within a room depends only on the presence of electricity within the room, so that, for instance, if the air which fills the room is charged with negative electricity, the potential observed will be negative notwithstanding any amount of positive electricity which may exist in the external air overhead.

The mode of observation was to employ as the collecting apparatus, the flame of a spirit lamp supported on an insulating stand connected by a fine wire with an electrometer. The potential was generally found to be negative, and of strength many times greater than the electromotive force of a Daniell's cell.

In order to exemplify the possibility of giving air an electric charge, observations of the kind above described were sometimes made after an electric machine had been at work either in the same room or in a neighbouring room with a short passage between. It was found that a few turns of the electric machine (a glass machine working in the ordinary way but with a spirit lamp burning on its prime conductor) were sufficient to reverse the ordinary indication of negative potential, and to give positive potential instead. A positively charged Leyden jar with its knob connected with the flame of an insulated spirit lamp gave the same effect. The flame served in these experiments to carry off electricity from the charged conductor with which it was connected, and to disperse this electricity through the air, as the hot gases from the lamp mingled with the air of the room.

Another very striking way of obtaining the same effect, was to put a negatively charged Leyden jar below the flame of a common gas-burner. The flame became positively charged by induction, and the hot gases from it accordingly carried off positive electricity, to be disseminated through the air. The action here is exactly similar to what goes on in the case of the water-dropping and burning-match collectors which we have described in the earlier part of this paper, except that those collectors were insulated, and could therefore give off only a small quantity of electricity, whereas the gas-flame which we are now describing is connected with the earth, and can therefore give off an unlimited quantity.

Observations were also taken of the potential at two different heights, in the open air, with the view of obtaining information as to the charge of the lower air. One of the two points at which the potential was observed was outside a window in the tower of the old College at Glasgow, and the other was outside a window of the Natural Philosophy lecture-room. It was found that the potential was sometimes, during several minutes, positive at the upper station and negative at the lower. After the indications had been negative for some time at both stations, the transition to positive usually took place earlier by several minutes at the upper station than at the lower; and sometimes during several minutes, preceded and followed by positive indications, there were negative indications at the lower station, and only positive at the upper. These observations concur with those taken indoors, in showing that the air, up to a height of several feet, is negatively charged.

Many causes have been suggested as possible origins of atmospheric electricity: such as evaporation, condensation, vegetable growth, and the friction of wind. It is known that high-pressure steam escaping from a safety valve, carries positive electricity into the air. On the other hand, steam laden with drops of oil, such as that which comes from the funnel of a locomotive, communicates to the air a negative charge. I feel convinced that friction, either of the air itself, or of solid or liquid particles contained in it, against the surface of the earth, is one cause of the generation of electricity in the air; a belief which is largely founded on the very strong indications of positive electricity which I always observed in Nova Scotia when there was high wind with keen frost, the air being usually loaded at the time with fine particles of ice. The subject is one which strongly demands further investigation. Strange to say, although there were brilliant displays of the Aurora Borealis during my observations, the indications of potential seemed to be altogether unconnected with them.

One great want at present is balloon observations on atmospheric electricity. Such observations should be directed to determining the difference of potential between the air at different heights. As no earth connection can be obtained in balloons, it would be necessary to employ two collectors at different heights, perhaps two burning matches let down from the balloon to different distances. One of the collectors must be in connection with the outer case of the electrometer, and the other with its electrode. Such observations would show the quantity of electricity in the air at all heights, from the surface of the ground up to the highest point reached by the balloon.

5th February, 1878.

The President, ROBERT YOUNG, Esq., C.E., in the Chair.

WILLIAM GRAY, ESQ., read a Paper on

THE ANTIQUITY OF MAN GEOLOGICALLY CONSIDERED.

12th February, 1878.

Robert Young, Esq., in the Chair.

A Paper by Mr. Robert Warren, of Ballina, was read,

ON THE OCCURRENCE OF SOME RARE BIRDS IN THE COUNTIES OF MAYO AND SLIGO.

Amongst the rare birds, visitants to Ireland, that have appeared in this neighbourhood, I may mention the Greenland Falcon, Snowy Owl, Pied Flycatcher, White Wagtail, Yellow Wagtail, Spotted Redshank, Green Sandpiper, Avocet, Iceland Gull, Glaucus Gull, Pomarine Skua, Richardson's Skua, Long-tailed Skua, Fulmar Petrel, and Great Shearwater; and the circumstances regarding their discovery and capture may prove of some interest to the sportsman, as well as to the lover of ornithology.

The *Greenland Falcon* (*Falco caudicans*).—This beautiful bird, the finest and handsomest of all the falcons, has visited the County Mayo on three occasions, and has been captured in every instance. The first bird obtained was an immature one, and is mentioned in Watters's Natural History of the birds of Ireland as having been shot near Ballina, in December, 1847. The second, a beautiful adult male, was shot by the late Mr. Reilly of Belmullet, near that place, in the winter of 1868, and is now in the collection of the Dublin Natural History Society; and the third, a lovely adult female, was shot by a young farmer, near Killala, the 3rd of April, 1875, and he told Col. E. Knox, to whom he presented the bird, that it was shot in the act of feeding on a kid that it had killed; this statement, if true, proves the strength and courage of this fine falcon, and also accounts for the high value set upon this bird by the old falconers. This falcon is of such rare occurrence in Ireland, that Mr. Thompson knew of only two specimens, both taken in the County Donegal; and Watters, besides one shot near Ballina, speaks of one shot near Drogheda, in 1851. It appears to be of equally rare occurrence in England; for in the new edition of Yarrell, the capture of only six specimens is recorded, and of nine in Scotland.

The *Snowy Owl* (*Strix nyctea*).—Three individuals of this noble species have visited Mayo, two of which were captured. The first was taken alive at Ballycovey, the residenee of Mr. Clive, in the autumn of 1851, and afterwards presented to the London Zoological Gardens. The second was shot by the late Mr. Thomas Palmer, in his demesne of Summer Hill, near Killala, the 26th of January, 1856; and another bird was seen by Mr. Palmer's son at the same place, in November, 1860. The snowy oil is a rare winter visitant to Ireland—so rare in its occurrence that Mr. Thompson mentions only ten specimens as having come under his notice, up to the date of the publication of his birds of Ireland.

The *Pied Flycatcher* (*Muscicapa Atricapilla*).—The first individual of this species ever known to have visited Ireland appeared in the lawn at Moy View on the 18th of April, 1875. My attention was attracted by seeing it catching insects in true flycatcher style; and it appeared to me so strange that a flycatcher (our latest summer visitor) should be seen so early in the season, that I watched it attentively for some time, and observing that it had a much smaller and neater head, as well as closer and more compact-looking plumage than that of the spotted flycatcher, as well as a faint appearance of white on the wing courts, I began to doubt its being of that species, so on the following day, to solve my doubts as to the species, I shot it, and then found it to be an adult female pied flycatcher. The specimen can be seen in the Museum of the Royal Dublin Society, to whom I presented it. This bird was a very rare straggler here, and, according to the new edition of Yarrell, by Professor Newton, it is not generally distributed throughout England, but very restricted in its haunts, its head quarters being some localities of the Lake district of Cumberland and Westmoreland, where it is most abundant.

The *White Wagtail* (*Motacilla alba*) has once appeared here. On the 25th of April, 1851, I observed a wagtail feeding in a newly-sown field at Bartragh, whose quiet movements and light gray plumage attracted my attention as something strange and unusual—for at that season all our pied wagtails have assumed the dark plumage of the breeding season—so I shot the bird, and on examining it, came to the conclusion that it was the true *alba*; however, in order not to depend upon my own judgment, and wishing to have a more experienced opinion as to its identity, I sent the bird to my old and valued friend Dr. Harvey of Cork, whose opinion agreed with mine as to its species. Wm. Thompson never met with this bird, and only speaks of Dr. Ball having seen a wagtail near Dublin, in June, 1846, that he thought was of this species.

The *Yellow Wagtail* (*Motacilla Raii*) has once appeared in this neighbourhood. On the 15th of April, 1875, a fine old male, in the most brilliant yellow plumage, visited one of the fields here, but remained for only one day, following the plough to feed on the grubs, &c., turned out of the soil. It was very tame, and allowed me to approach very closely to observe it; and although I was very anxious to secure it as a specimen, it looked so handsome and confiding that I thought it a pity to shoot it. In his birds of Ireland, Mr. Thompson states that this wagtail is a regular summer visitor to the southern shores of Lough Neagh, but only an occasional and rare one to other parts of Ireland. He also mentions having seen forty birds on Derrynarragh Island when visiting it, accompanied by the late Mr. J. A. Garrett and Mr. Darragh, on the 4th of May, 1850.

The *Spotted Redshank* (*Totanus fuscus*).—The first specimen of this rare bird of which we have any authentic record as Irish, was that obtained by the late Wm. Thompson, near Holywood, on the 22nd of August, 1823, and mentioned in his 2nd volume of the birds of Ireland; and, strange to say, from that date up to 1867, a period of *forty-four* years, there is no record in any ornithological work that I am aware of, of a second specimen of the spotted redshank being captured in Ireland; nor am I aware of any museum either public or private holding an Irish killed specimen previous to that date. There is no doubt of the bird occasionally visiting Ireland at the autumnal migration, but owing to its resemblance to, and feeding and associating with, the common redshank, it almost always escapes notice, and indeed unless its very peculiar call note attracts the notice of the observer, it is a hundred chances to one that it passes unnoticed amongst the other shore birds. The few instances in which this bird has come under my notice, and the facts regarding the capture of the two specimens that I was so fortunate to obtain, are as follows:—

The first bird I obtained quite unexpectedly. On the 14th of January, 1867, I was returning from snipe shooting in a small marsh at Killanby, near the Moy, and walking along the shore, I observed at about forty yards distant what I thought was a common redshank, feeding on a little mud-bank left bare by the receding tide. The evening became too dark for shooting, so wishing to discharge my gun before returning home, I took a chance shot at the bird, and fortunately knocked it over; my dog fetched it in, and on taking it from her, I merely remarked that it differed from the common redshank in the greater length and delicacy of its bill and legs, there not being sufficient light to perceive any difference of plumage, and thinking it merely a variety of the common redshank I put it into my bag along with the other birds I had shot. However, next morning I at once recognised the long-wished for spotted redshank. This specimen was most beautifully set up for me by my old and esteemed friend Mr. Darragh, and is now in the fine collection of Dr. Harvey of Cork.

In January, 1869, my attention was first attracted by the peculiar call-note of a Sandpiper seen flying very high, passing over Roseck Abbey; and as I never before heard a similar call, I felt puzzled as to what bird it was. Again on the 13th of Sept., same year, I started a sandpiper off the Moy View shore which uttered the same peculiar cry, and surprised me by its wild and powerful flight. It rose from the shore like a wild snipe, soaring to a great height, and going off right out of sight. I next heard this peculiar call near the Island of Baunros on the 15th of November, 1871; and again on the 27th of October, 1874. My next meeting with this bird was on the 23rd of April, 1875, when passing Baunros in my boat, but the bird was, as usual, so wild that I was unable to get a shot at it; however, being so often disappointed in either obtaining or identifying it, I decided upon devoting the following day to endeavouring to secure the bird, or to ascertain what it really was. So I went in my punt to Baunros, and found the bird associating with some redshanks, as it usually did when resting after feeding on the shore at high-water, though at other times it was generally alone. I landed on the island with the intention of shooting it from over the bank, but found the bird so very wary that it was impossible to stalk it, and obtain a sitting shot, and I was unable to take a flying shot from the difficulty of distinguishing it from the others until it was out of range. It thus baffled me several times, but seeing it join some redshanks on the other end of the island, I saw my only chance of shooting it was from the boat, so lying down, I set the punt quietly down to the flock, amongst which I noticed a very dark-coloured bird, so unusually dark for a redshank, that I was certain it was the bird I was after. I also saw a very light-coloured bird, which I took to be one in winter plumage, so I fired at, and knocked over the dark bird, which, much to my disgust, turned out to be a common redshank in summer plumage, and the light-coloured I passed over proved to be the bird I was so anxious to obtain. After the shot it became so wild that I was unable again to approach within range, though I waited until darkness compelled me to give up the pursuit for that evening; and when I returned a few days after, to look for it again, I found it had left the locality altogether for the season: but though I failed in obtaining the bird, yet I felt pretty certain it was the rare spotted redshank.

On the 4th of September, 1876, I again heard the wellremembered call, and saw the bird flying along the shore here; and on the 17th of October, when at Roseck waiting in my punt for a shot at some lapwings, I heard the call of the sandpiper, and immediately after, it passed within a few yards of me and alighted on the shore close by. From the near view I had of it I was almost certain it was the true *Totanus fuscus*, especially as its dark wings contrasted so strongly with the white barred wings of the common redshank; but to make quite sure I set the boat quietly up to where it was resting, and got within eight or ten yards—sufficiently near to see distinctly the long slender red legs and bill, and peculiar looking dark streak between its bill and eye, proving satisfactorily that it was the true spotted redshank, whose peculiar cry and wild and erratic flight had puzzled me for so long. I lost the opportunity of obtaining it on that day, by omitting to have my small gun on board, and until the 30th of that month I got no chance of shooting it. On that day, I was down the river to Bartragh with my punt and gun, and returning by the islands, near Roseck, I saw some lapwings and redshanks resting on the shore of one of the islands; and wishing to obtain a shot with the big gun, I set the boat up to them, but when within range I found the birds so few in number as not to be worth a sho ; so I let the punt drift on until I came within a few yards of where the redshanks were sitting, and there I recognised the *fuscus* amongst the flock, but I was so near as to be unable to take up my small gun without alarming them, nor could I back the punt from them, as the wind drifted her right down, but I hoped she would have drifted past without disturbing the flock; however, the redshanks made off, leaving the other still on the shore, but when the punt got within six or eight yards, he ran along the shore for a few yards calling loudly, and then took flight to the shore of a small island a couple of hundred yards away. Seeing that he was alone, I felt sure of obtaining a shot, as he appeared to mind the punt far less than the other birds, though so unapproachable by land; so I quietly set up to where he was standing behind a stone, and after a little management I succeeded in obtaining a fair shot, and knocked over with a charge of No. 4, the third specimen of the spotted redshank ever known to have been captured in Ireland.

This season of 1877, we had another visit from the spotted redshank, and it haunted the shores of the estuary for some weeks in October and November; but owing to the long continuance of stormy weather, I was unable to make any attempt at securing it, and I think the heavy gales we had at the end of November drove it out of the bay altogether: for since the 17th of November, I have neither heard nor seen the bird, though constantly on the look out for it at its old haunts.

The *Green Sandpiper* (*Totanus ochropus*) is a very rare visitor—only four birds have been met with in this locality; and as all four were observed on the banks of a little lough here at Moy View, it appears to have some special attraction for birds of that species. The little lough is about thirty yards in length by six or eight in width, and is separated by a wall from the shores of the estuary; on the other sides it is surrounded by low trees, having a few yards of flat grassy bank between the water and trees. The first green sandpiper I ever met with, appeared here in January, 1866; but owing to its watchfulness I was unable to shoot it until the 12th of that month; and my friend, Mr. A. G. Moore, met a pair at the same place on the 25th of August, 1873, one of which he shot; and again, on the 2nd of September, this year, I observed a bird at the lough, and managed to obtain it on the 4th of that month—it is evidently a young bird of the year.

The *Avocet* (*Recurvirostra avocetta*) is very rare, and has only once come under my notice. On the 28th of October, 1875, I was returning from Bartragh in my punt, with the gun unloaded, when just before reaching the landing place, I perceived a pair of birds feeding with some greenshanks, in the shallow water on the sandbanks. They looked so very white in the evening light, that at first I took them to be albino greenshanks; however, as the boat approached, the latter birds went off, leaving the others still feeding. When I got closer I saw that they were avocets. Being very tame and unsuspicious, they allowed the boat to approach within eight or ten yards, from which distance

I watched them feeding for a long time. I was much interested in their very peculiar mode of using their curiously formed bills. On the following day I met them resting on the shore at high water; and on disturbing them in attempting to obtain a shot, they moved off about two hundred yards, and pitched in the shallow water off the bank, and then, much to my surprise, swam boldly out against the wind, rising over the little waves as buoyantly as ducks, and remained out of shot until the tide receded, when they moved to the side of the bay, thus proving that they could make good use of their semi-palmated feet. As I was unable to secure them myself, I asked my friend, Captain Dover, to look out for them, when out with his punt gun; and in two days afterwards he obtained both birds at a shot, one of which he kindly gave to me, and presented the other to the Royal Dublin Society's Museum.

The *Iceland Gull* (*Larus islandicus*) is occasionally seen in winter, though not every year, and those met with are generally immature birds. I have seen only one adult bird; and on two occasions I think I saw birds in the first year's plumage. I have met them in the years 1851, 1854, 1855, 1862, 1866, 1873; and on the 28th of January of the present year, I saw a young bird resting in one of my fields along with a flock of common and black-headed gulls.

The *Glaucus Gull* (*Larus glaucus*) has not come under my notice nearly so often as the Iceland gull, nor have I obtained so many specimens. In 1859 I first met this fine northern gull, during a heavy fall of snow, on the 14th of December, and although I fired at, and severely wounded it, it unfortunately got away. In March, 1871, I saw an adult bird on two occasions, but was unable to secure it; and several times during January, 1873, I saw another, also an adult, about the sands and river, and at length, on the 23rd of the same month, I succeeded in shooting it, near Ballysokeiry. It was a very fine bird, showing a little of the dusky tinge of winter plumage about the head and neck. This specimen is now in the Royal Dublin Society's Museum. Again, in the winter of 1874 or 1875, I shot an immature bird. During the past winter, I several times observed a glaucus gull about the river and estuary; and as I was passing up the Moyne Channel, in my punt, on the 28th of March last, it flew close by me, and I could not resist the temptation of bringing it down. It proved to be a beautiful adult bird, in the lovely summer plumage. As far as I have seen, the glaucus gull is far more wary and distrustful than the Iceland gull, the latter showing very little fear of man when first they arrive from their arctic haunts. It is remarkable that up to the publication of the late Wm. Thompson's "Birds of Ireland," the glaucus gull appears to have visited the country far oftener than the Iceland gull,—Thompson only mentioning four specimens of the latter gull that came under his notice, while he speaks of eleven of the glaucus being captured at various times, as well as others seen.

The *Pomarine Skua* (*Lestris pomarinus*).—Several flocks of this fine skua appeared here, migrating to the southward on the 22nd and 23rd of October, 1862, during very stormy weather. The wind was blowing in wild squalls with heavy showers from the south-west. On that morning I was standing at the parlour window, looking down the river towards Bartragh, when I remarked a flock of ten or twelve dark looking birds flying slowly up the river from the sea. I immediately took up my gun, and hurried down to the shore to meet them, but only reached it in time to see the skuas pass out of shot; however, my disappointment did not last long, for in a few minutes after, a flock of fine birds passed, out of which I was so fortunate as to obtain a beautiful specimen of the Pomarine skua, in nearly perfect adult plumage. Several flocks passed on afterwards, and I was able to secure a second Pomarine in like state of plumage. On the morning of the 23rd, the gale still continued, but had changed round to west-north-west, and the skuas, in consequence of this change of wind, kept along the western or Mayo side of the river, never coming within shot of the Sligo side, upon which Moy View is situated. I had an excellent opportunity for observing those that passed on the 22nd, and have little hesitation in considering the greater part, if not all, to have been Pomarines. The first flock of ten or twelve birds were undoubtedly of that species, their thin form, large size, and clumsy looking tails clearly pointing them out as such; and all exhibiting white underneath, and long tails, which characters prove them to have been adults. When seen during flight the Pomarine skua's tail presents a very clumsy awkward appearance, in contrast to the elegantly pointed tails of the smaller species of skua; this is caused by the two elongated tail feathers being bluntly rounded at the ends, and twisted for nearly half their length at almost right angles to the plane of the short tail feathers, so that when a side-view of the bird is taken, the full breadth of the long tail feathers is shown, giving the tail that thick clumsy appearance which so easily identifies the Pomarine skua on the wing.

Richardson's Skua (Lestris Richardsonii) first came under my notice in October, 1857, when residing with my brother, Mr. E. H. Warren, on the Island of Bartragh. He first observed the skuas on the 8th of October, when two flocks of six and eight birds were seen at a great height, flying to the south-west. On the 15th, the weather being very stormy, the birds kept low in passing, and we counted seventy-two birds as they crossed the Island, coming from the open sea in small detached parties, all keeping the same course across the country to the south-west. On the 16th, the migratory flight still continued, and we counted upwards of one hundred passing in a very short space of time; but as we were only able to watch them for about three hours each morning—between eight and eleven o'clock—it is very likely that only a small part of the main flight came under observation. From the fact of my brother having seen skuas pass every year, during the month of October, for the five years of his residence on Bartragh, I have little hesitation in coming to the conclusion, that there is a yearly migration of skuas to the south from their northerly breeding haunts, and that their line of flight is into Killala Bay, passing over the Island of Bartragh; but that it depends altogether upon the state of the weather at the time of passage, whether they are seen or not. If the weather is stormy, with wind from the southward, they will fly low, taking advantage of the shelter of the land, but if it is bright calm weather, they keep on their course at a great height, out of sight or nearly so, as I saw a flock passing on the 18th of September, 1869.

I was in the harvest field watching my reapers at work, at about ten o'clock, and chancing to look upwards, my attention was drawn to a flock of fifteen skuas, passing at an immense height, on their old course to the south-west, and if the day had not been so clear, I could not have recognized them as skuas, as I was barely able to make out their long tails against the clear blue sky. I have occasionally observed and shot solitary birds of this species at various times during the two autumnal months, but I have only once met them in the spring, and that was in May of the present year, when a party of six birds accompanied a large flight of common and Arctic terns, visiting the bay and estuary. Three of the skuas were in light-coloured plumage, and three in the very dark; and I fancied at the time, from seeing a light and a dark bird keeping company, that the colours marked the male and female; and so, in order to ascertain this fact, I shot three birds, one having the pure white throat and breast, the white extending all round the back of the neck, causing the dark colour on the head to look like a black cap; the second having only the white breast, with a tinge of light colour on the sides of the neck, similar to the first one; and the third bird was quite dark all over, except a slight tinge of lighter brown on the breast and throat, and all had long tails, showing they were adult. However, much to my surprise, on skinning and dissecting them, all three proved to be females, the ovaries of each containing eggs, varying in size from No. 8 shot up to B.

The *Long-tailed Skua* (*Lestris longicaudatus*) is very rare here; two specimens only coming under my notice. On the 24th of October, 1862, I was on the shore, near Scurmore, where a small skua flew past, which I fired at and wounded, but it escaped over the sand-hills. On the following day, when walking over the Enniscrone lands on the other side of those sand hills, I picked up a small skua lying dead, near high-water mark, and fancied it was the one I fired at the day before. After I got home I skinned it, and found that it had been wounded with the same shot I used, so I felt certain it was the bird I had wounded. This was an immature long-tailed skua. The second bird was given to me on the 18th October, 1867, by Mr. N. Handy, of Ballintubber, near Killala, who told me he met it when out grouse shooting, and shot it as it rose from the carcase of a horse upon which it was feeding.

The *Fulmar Petrel* (*Procellarea glacialis*).—This bird is so very rare in its visits to Ireland, that Mr. Thompson knew of only three specimens having been obtained;—the first shot at Inchidoney Island, on the southern coast, by Captain Hungerford; the second shot on the North Strand, Dublin Bay, in January, 1846; and another at Castlefreke in the County Cork, by the Rev. Joseph Stopford, in October, 1845. It has on several occasions been found thrown up dead, and in two instances alive, by the surf on the sands of Enniscrone and other parts of the shores of the estuary and bay. On the 24th of January, 1857, I found a young bird in what I think was the first year's plumage, on the Moy View shore, having been brought by the tide from the bay. This bird was so fresh and in such good condition that I sent it to Dr. Harvey of Cork. On the 24th of October, 1862, I visited the Enniscrone lands to look for any storm-driven birds that might have been thrown ashore by the surf after the northerly gale of the night before, and in the course of my search I saw a black-backed gull dragging and trying to tear something that was lying partly in the water, and had just been cast ashore by the surf. On reaching the spot I found an adult fulmar in a most wretched condition, completely water-soaked, and so weak as to be unable to stand, and it died shortly after I put it into my bag. Shortly after, I saw the same gull a few hundred yards off, watching something he feared to attack. I at once hastened to the spot, and found a second fulmar just come ashore, and as miserable looking as the first bird, except that it was not so weak, being able to walk a little, and deter the gull from attacking it. These two, when the plumage dried, made beautiful specimens, and are now in the collection of the Dublin Natural History Society.

On the 3rd of October, 1865, I found another fulmar thrown up on the same part of the lands; but though quite fresh it had been destroyed by the gulls. On the 3rd of October, 1867, I picked up a fulmar on the same sands, so fresh and uninjured that I sent it to the Dublin Society's Museum; and on the 21st of October, 1868, I got another, which is now in the Belfast Museum. On the 4th of March, 1870, I found the remains of one destroyed by black-backed gulls on the Bartragh lands; and during the winter of 1872 or 1873, I got a very fine bird on the Enniscrone lands, which I have had set up for myself. I have very little doubt that if the sands were regularly searched in the months of October and November, specimens of the fulmar would be found every year in Killala Bay; but if not found immediately after they are cast ashore, the black-backed gulls always, vulture-like, on the look out for prey, destroy them, and in a few hours the torn remains are covered by the drifting sands.

The *Great Shearwater* (*Puffinus Major*) has only once been found. When visiting Downpatrick Head, with some friends, on the 22nd of August, 1859, we obtained a dead bird, in the brownish plumage of the first year, from a man who had picked it up on the rocks a few minutes before, along with some razor-bills and guillemots. The specimen was quite fresh, and had evidently died only a few hours before, but had been too much knocked about for setting up.

12th February, 1878.

The President, ROBERT YOUNG, Esq., C.E., in the Chair.

Mr. W. H. PATTERSON read Extracts from Mr. WM. HANCOCK'S Letters on

NOTES OF A TRIP IN THE NEIGHBOURHOOD OF NINGPO, CHINA.

12*th March*, 1878.

The President, Robert Young, Esq., C.E., in the Chair.

Mr. Joseph John Murphy contributed a Paper on

COLOUR AND MIMICRY IN ANIMALS AND PLANTS.

[This paper is to form part of the new edition of Mr. Murphy's "Habit and Intelligence," and consequently is not printed here.]

26th March, 1878.

R. L. Patterson, Esq., in the Chair.

Surgeon-Major Walter Fry read

NOTES ON THE BIRDS OF THE TRAVANCORE JUNGLES.

2nd April, 1878.

Robert Young, Esq., in the Chair.

A Paper was read by J. Harris Stone, Esq., B.A., F.L.S., F.C.S., late Scholar St. Peter's College, Cambridge, on

THE INTERDEPENDENCE OF ANIMALS AND PLANTS.

The object of this paper is to place before you the main arguments for the assertion that while animals are dependent on plants for their very existence, plants would no longer be in the universe were animals excluded. The subject is a large one—it has many points of intense interest to every thoughtful mind, whether from the biological aspect, or to the theologian; and the mere theorist will find food in it for many an hour of quiet speculation. I am unable to advance any new facts, but I will endeavour to lay before you on a broad and general principle the leading features of the subject, so that those of us who are not acquainted with it may be able to grasp the idea of the entire interdependence of plants and animals, and I only trust the subject will be as interesting to you as it has been to me in collating my materials. On those points with which I am more intimately acquainted I shall dwell at some length, because I feel that here, at any rate, by lengthened explanations, I may perhaps be able to illustrate more forcibly what I could not, through ignorance, do with many portions of this vast subject. There are many things I shall have to say that will be familiar to most of you, but feeling that by omitting them I should be laming my whole case, I must ask you kindly to bear with me.

Believing that we cannot too thoroughly understand and grasp the very simplest facts of science, I shall allude to some of the most elementary details of scientific knowledge, and from them, as on a sure foundation that has stood the test of many waves of scepticism and doubt, build up the main points of this evening's discourse.

Generally speaking, every one will be disposed to say that the subject we are discussing is self-evident; thus, it is obvious that animals eat plants, and in a large measure depend upon them for sustenance, while plants again in some way derive food for vegetable growth and development from dead animal matter, so that the two play into each other's hands; and the Omniscient Creator has without doubt ordained that the two great divisions of life should lean for support on one another. This is all quite true, and we only propose to look, this evening, a little closer, a little more truthfully into the matter—or scientifically, if you prefer it—and in a measure to unravel the threads, as far as our time permits, which bind these two great divisions of organic nature together. There is a well-known and well-authenticated case of how, in a certain place, the phenomenon of a kind of clover bearing seeds was directly influenced by the number of cats that were to be found in the neighbourhood. At first sight this certainly seems remarkable, that cats should influence the pods of the clover, and imagination would perhaps suggest a series of events following as directly on one another as those related in the traditional "house that Jack built." Such a thought is not unreasonable, for in the case of the cats and clover it is on this wise:—the clover is fertilized and bears pods, through the agency of the humble bee conveying the pollen of one flower to the stigma of another. Now, these bees make their nests in the ground, and the comb and pupa, the dainty bits, are a favourite food for field-mice; hence the number of nests, and consequently of bees, are directly dependent upon the field-mice: it is well-known that the quantity of mice varies with the number of cats kept; hence if there are many cats, they eat the mice, and prevent them from destroying the nests of the bees, and consequently the bees can increase in number without let or hindrance. In such a state of "low" life, the bees are in abundance to fertilize the clover, and so pods will appear upon it in plenty. This instance somewhat graphically puts before us the wide-spread fact that in nature, as in many problems of social life, there are wheels within wheels, causes contingent upon causes, and affords another example of what may be said to be a general rule, propounded by Dean Swift, that

> As naturalists observe, a flea
> Has smaller fleas that on him prey,
> And these have smaller still, to bite 'em,
> And so proceed, *ad infinitum*.

The most important point in the consideration of the interdependence of plants and animals lies, beyond doubt, in the influence they exert on the surrounding atmosphere. In order that we may more thoroughly grasp the importance of this fact of the consumption of oxygen by animals, and the evolution of carbon in the shape of carbonic acid gas, let us take the case of one animal—and that one, for instance, most familiar to us—*homo sapiens*. A healthy man on an average, during the twenty-four hours, will inhale oxygen, and give out enough carbonic acid gas to yield eight ounces of pure carbon. Now, every man and woman doing this, and taking a very low estimate of the population of the globe, I should say from this source alone 300,000 tons of pure carbon are poured out into the atmosphere each day. But, besides this, every other animal is doing just the same thing, so that the total amount of carbonic acid gas, and consequently of carbon, given out to the air from the animal kingdom is impossible to be calculated. Now, carbonic acid gas has such properties that animal life cannot exist in it; hence it follows that, looking at the enormous amount of it that is perpetually being made from animal respiration, and from all fires, &c., there must be some agency simultaneously at work, removing it as fast as it is made. Plants do this. They have the power of splitting up the carbonic acid gas; retaining the carbon in themselves for the purpose of growth and development, and giving back to the atmosphere that part they do not require—the oxygen. Thus animals play into the hands of plants, and plants in turn repay the compliment by generously restoring what they do not want, but what is of vital importance to animals—the oxygen. So the balance of the atmosphere is kept right, and the composition of it, all over the world, is the same, with extremely slight variations.

We have been considering the case of animals being directly, or, in the case of flesh-eating animals, indirectly, dependent upon plants for their food. Now we pass on to consider the reverse of this, and glance merely (for I treated this subject fully at a lecture I had the pleasure of giving before you last year)—we must glance, I say, now merely at the case of plants deriving a very large portion of their sustenance from the animal kingdom. They are known under the name of insectivorous plants. Such plants possess certain common characters—namely, the paucity or even entire absence of roots, the high development of the leaves, and the occurrence of electrical phenomena, which have their parallel only in animals. We may take, for instance, the common sundew (*Drosera rotundifolia*), a plant that grows in abundance on the Mourne Mountains. When I before addressed you on the subject of carnivorous plants, I was not able to assert that they benefited directly by their carnivorous acquirements, though I mentioned it then as highly probable ; since then, in a paper read by Mr. Francis Darwin before the Linnean Society (January 19, 1878), he communicates the results of a number of carefully-performed experiments, showing that insectivorous plants are largely benefited by their animal food. From this we see that the advantage gained by the fed plants is far more conspicuously shown in all that relates to the seeds and flower-stems than in any other way. The experiments have been most expectantly looked forward to by all biologists, and they seem clearly to establish the fact, that these plants are greatly benefited by animal food, and it can no longer be doubted that a similar benefit is gained in a state of nature by the capture of insects. The part which plants play in this mutual economy may be characterised as synthesis, for they take simple substances, building them up from the inorganic world into organic substances which just suit as food for animals. The process is one also of deoxydation, oxygen being given off. Animals taking as their food these substances prepared for them by plants, digest, absorb, and assimilate them, and so grow, develop and live, but eventually oxydize them, and reduce them once more to their inorganic constituents of carbonic acid, ammonia, and sulphates. These ultimate products once more are in a state to serve as food for plants, and so the cycle is completed—plants building up out of simple materials complex substances, and animals taking these substances, and, by digestion and the operations of living, undoing the work, returning to the vegetable world the constituents which it needs, and is able to use as food. In this way the balance between the two great divisions of the organic world is maintained, and the existence of each insured. Though, therefore, it is physiologically quite true, as Shakspeare says, that—

> Imperial Cæsar, dead and turned to clay,
> Might stop a hole to keep the wind away,

still, the elements of what Imperial Cæsar was composed, after passing through a stage in plant life, might once more appear in the world with a manly or a womanly face.

I should allude—even if that is all—in passing on to more interesting topics, to the dependence of animals more or less upon trees for water. This may be called one of the indirect examples of the interdependence of animals and plants, but it is nevertheless most important in the economy of the world. As a general rule, trees, for numerous causes which we have not time to discuss, and which I will ask you, therefore, to take for granted, promote the humidity of a country, increase its rainfall, and therefore exercise a most important influence upon the nature, character, and number of the animals which inhabit that country. Were the Sahara abundantly watered, we should, in the place of a dreary expanse of sand, have a region teeming with life; animate nature in profusion; birds, beasts, and plants vying with each other in the struggle for existence—a state of things represented at the present only by the exceptional quarrellings of beasts of prey over the remains of some belated traveller or his equally unfortunate camel. Whether or not it is possible to flood the Sahara, and what would be the effect of so doing upon the climate of Europe, is not in our province this evening to enter upon. The subject, however, is most interesting. We can all see at once how, indirectly, the habitat of certain animals, and so, consequently, in a measure, their life, will depend upon the amount of marshy land in a country. For instance, were Lough Neagh drained, many birds that frequent its shores would have to decamp and find food and dwelling in other countries, and in this train of thought we can quite fancy that their arrival at some spot where they were not wanted might seriously derange the harmony of the native bird-population, leading to disastrous results, perhaps even to bloodshed. Thus, man's interference with the natural surface of a country may very materially affect its fauna. Numbers of other instances of effects produced on the animals of a country by the removal or planting of forests will present themselves to your minds on thinking over this most important subject.

We need now say nothing further. There are some miscellaneous interdependencies of animals and plants which are most strange and interesting. The first example under this head, on which I would say a few words, is the leaf-cutting ant of tropical America (*Œcodoma*). These ants have been described by many travellers. Their crowded, well-worn paths through the forests; their ceaseless pertinacity in the spoliation of the trees, which are left bare and ragged, with the midribs and a few jagged points of the leaves only left. They attack particularly introduced species of trees. The leaves are cut out by the scissor-like jaws of the animal into pieces about the size of sixpences; each ant mounts the tree in succession, cuts off its piece, and then rapidly descending, hurries off to deposit it in the nest. As it proceeds, other paths, each thronged with busy workers, come in from the sides, until the main road often gets to be seven or eight inches broad, and more thronged than the streets of the city of London. The bystander might exclaim—"I looked towards Birnam, and, anon, methought the wood began to move." Though these ants are so well-known and so often described by travellers, there has been much doubt as to the use to which the leaves are put. Some have supposed that they use them directly as food, others that they employ the leaves to roof their underground nests. That careful observer and admirable writer Mr. Thomas Belt, to whom I am indebted for the account of these interesting animals, gives it as his opinion in his book, "The Naturalist in Nicaragua," that they make use of the leaves as a manure, on which to grow a minute species of fungus, on which they feed.

Perhaps the most wonderful instance of the interdependence of animals and plants lies in the fertilization of the latter. Though at first sight improbable, yet every discovery of recent years seems to point to the conclusion that it is exceptional for a plant to be fertilized without the aid of insects. Thus, for instance, it appears that the vast order of the Cruciferæ, with one solitary exception, is totally dependent upon insects for its fertilization.

Not only are flowers fertilized by insects, but also by birds, particularly by humming birds. A plant found in tropical America—*Marcgravia Nepenthoides*—has a number of pitcher-like vessels suspended from the centre of a circle of flowers. These are filled with a liquid attractive to insects, and consequently numerous insectivorous birds frequent them. Now, the pitchers are so disposed that the birds, to get at the insects, must brush against the anthers and carry away the pollen, so that in their visits to different flowers the pollen is conveyed from one to another. In these few typical examples of the fertilization of plants by animals we see one of the closest bonds of their interdependence. And this has often been prominently brought out in those cases where plants have been introduced into foreign countries without their attendant insects. The scarlet runner has been repeatedly tried to be introduced into other countries, but, though growing luxuriantly, never bears a pod. Now, the scarlet runner depends on the humble bee for its fertilization. It is useless, therefore, trying to introduce this plant without also introducing simultaneously the busy humble bee.

Last summer (1877) I grew for experiment a number of sweet peas in my small garden, fronting the Lisburn Road, Belfast. I should scarcely think at any time it would be a favourite spot for insects, but last summer was so wet that I never saw a bee in the garden, though I was always on the look-out for them. Not one of my sweet peas bore a pod, except those flowers that I artificially fertilized with a pencil point. And this was, without doubt, owing to the great scarcity of insects last summer in this neighbourhood. The peas, however, remained in full bloom a very much longer time than usual, waiting for the friendly visits of their allies. Those that I artificially fertilized soon faded and drooped, whereas neighbouring flowers that had opened at about the same time, but which I had not fertilized, still remained in all the beauty of their colours and odours.

Having, then, gone most rapidly along the main road of our subject, and avoided pursuing any of the innumerable side-paths and offshoots that presented themselves at every turn, I would, in conclusion, go back to the point from which we started—the consideration of the title, "The Interdependence of Animals and Plants. I would preface those remarks, as by analogy bearing directly on the subject, with a few words upon a theory as to the constitution of matter, which in some form or other has had its supporters in all the ages of which we have record. Thales of Miletus, the first of natural philosophers, Anaximenes, Heraclitus, Aristotle, Homberg, Boyle, Prout, and a host of names in the Middle Ages, down to Professor Cooke of our time, have all more or less leant to this theory. Strange it is perhaps at first sight; almost stupendous in its ambition; but for its very importunity, if for nothing else, we should look it boldly in the face and endeavour to see if there be anything of truth in it—I allude to the theory of the Identity of matter, or as Professor Cooke puts it, "I must confess that I am rather drawn to that view of nature which has favour with many of the most eminent physicists of the present time, and which sees in the cosmos, besides mind, only two essentially distinct beings—namely, matter and energy, and which regards all matter as one, and all energy as one; and which refers the qualities of substances to the affections of the one substratum modified by the varying play of forces."—(*The New Chemistry*). Or, as

Professor Naquet says—"This idea well explains the fact that gravity acts equally on all bodies, and answers, moreover, to the idea we have rightly, or wrongly, introduced into science, of the simplicity of the great laws of nature."—(*Principles of Chemistry.*)

In these last few months this theory has certainly received some striking additional proofs in favour of its veracity. The discovery of the metal gallium, and the most remarkable manner in which it fell into its provided place in the natural series of the elements; the physicist's recent glorious victory over the hitherto refractory gases, when even hydrogen has yielded and made itself visible; when air has—on the last day of 1877—appeared in the form of a fluid, are all strong arguments in support of the identity of matter. Economy in the number of the materials used in building up the numerous forms, substances, forces, and powers that exist in the universe seems a law as evident as it is mysterious. The theory of the identity of matter seems to me to be nobler, grander, wider in application than any of those more prescribed which have been advanced as to the constitution of matter.

It is with some such thoughts as these that, coming to the end of my subject, I turn back and think,—is the title I have chosen, after all, a misnomer or not? Is there really any distinction between animals and plants? Should I have said, "The interdependence of animals and plants," or, "Some mutual relations of life?" I must own that the latter seems to me to be more correct. This idea I advance with great diffidence, feeling that it is more or less revolutionary; that some may not hold it consistent with the facts; that perhaps I myself may see cause to relinquish it. At the present moment, however, I find it utterly impossible to say what a plant is, or what constitutes an animal. So far as I have thought the matter out, this way of looking at the relationship of plants and animals removes all difficulties, and reconciles many anomalies. A definition of either has to be so qualified to include the numerous exceptions which, with the advance of scientific knowledge, are every day increasing, that the result is, no exclusive diagnoses are possible. As the doctrine of the identity of matter is simple, realizable, and comprehensive, so, I venture to think, is the idea that all life is the same—is the thought of the identity of life. In attempting to divide animals from plants, we are raising barriers which naturally do not exist. Has not all biological discovery and research for many years past been pointing that way with an inexorable hand? Nothing is more dissimilar than the ox and the grass he feeds on, the bee and the flower he visits in search of nectar; but when we come down to the lowest plants, to the lowest animals, we find ourselves in a very chaos of doubt and uncertainty. But this is not only the case on the verges of the kingdoms, but also all through them. We find there are moving plants: there is the sensitive plant, which

> Opened its fan-like leaves to the light,
> And closed them beneath the kisses of night.*

There are plants whose leaves and petals, stamens and styles, are quite mobile and apparently sentient—

> 'Twas a lovely thought to mark the hours,
> As they floated in light away,
> By the opening and the folding flowers,
> That laugh to the summer's day.†

Then there are fixed animals, incapable of locomotion; there are innumerable plants that move about in a perfectly free state; there are animals without stomachs or any digestive system; there are plants with organs which, to all intents and purposes, are true stomachs; there are animals that in appearance are similar to plants (how often do we see the sea-mat, or flustra, included in collections of sea-weeds); there are plants that exactly resemble certain animals; there are animals coloured with the same green pigment, chlorophyll, that gives the verdant colour to the plants; cellulose, a substance once said to be peculiar to the vegetable kingdom, is found in animals as well as in plants; the protoplasm of both animals and plants at some period of its existence is identical in its composition and properties, sensitive, contractile, mobile, consuming oxygen and exhaling carbonic acid gas, in death keeping up the similitude;

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* *Shelley.* † *Mrs. Hemans.*

though in the light plants exhale more oxygen than animals, in the dark they become very animals in their respiration ; some plants (fungi) regularly exhale carbonic acid gas ; in the embryology of each there are most remarkable points of similitude and analogy. There are undoubted animals that you may cut into as many pieces as you please, and in any direction, and each piece will at once grow into a perfect animal, just as you may take cuttings from a tree, and by planting them in the ground, turn them into trees like their parent. There are animals that bud off offspring as rapidly as a tree in spring throws off its leaf-buds, but the buds of such animals disconnect themselves, and each starts a separate existence, in this respect being, if possible, more vegetable than the tree to which we have likened them.

We hear of cannibals amongst men ; we have cannibals amongst plants. In Britain we have *monotropa*, which lives upon the roots of the beech and pine ; *epipogium* and *corallorhiza*, which latter have no roots at all, but imbibe the juices of their hosts through their stems. Such plants, indeed, do not require roots, for there is no work to be done by such organs ; for the nitrogenous compounds, instead of being laboriously made in themselves, as is done in most plants, are obtained ready-made from their fellows. A like reason explains the absence of the green colouring matter, chlorophyll, in so many of these plants. Amongst the mammalia, the young offspring of all species require to be fed and looked after till they reach a comparatively mature age. All seedling plants, while in a stage of helpless infancy, require, just as much as animals in a similar condition, to be fed. In this state they are unable to make food for themselves, or to procure it in any other way. Nature provides for this want by surrounding the young plant with a mass of highly nourishing food—the endosperm or albumen, as it is called—and from this it imbibes its nourishment until it has arrived at an age to look after itself. I am not straining the analogy too far here, for experiment has shown that this endosperm can be removed, and other placed instead of it, without injury to the young plant.

So we might continue summarizing the apparent anomalies of the two kingdoms ; but these, when viewed in the light of this theory, sink into characteristics which might be expected. With the advance of microscopical science, the list of organisms to which no place can be assigned in the general system of natural classification is increasing, and for these unfortunates, rejected alike by botanists and zoologists, some people would make an intermediary kingdom, a sort of "Tom Tidler's Land." But may it not be possible, and is it not probable from the facts, that there is no distinction ; that animals, on the one hand, pass by fine gradations into plants ; plants glide by imperceptible stages into animals—that as I have before said, there is such a thing as the identity of life ? At least such a way of looking at the problem of living beings, both what we are accustomed to call plants and animals, is a simple one, and it removes many difficulties. It seems to me to be a higher, a loftier, a more comprehensive view ; to be more in harmony with the general, yet at the same time minute, laws that govern the universe so far as we know them ; to be in keeping with the revelations of Divine truth, with the dealings of the Great Creator, and—though perhaps time and new facts may disprove it—yet a help for us now to realize that greatest of all generalizations, that

The laws of nature are the thoughts of God.

18th April, 1878.

The President, Robert Young, Esq., C.E., in the Chair.

Dr. Gilbert Kirker read

NOTES ON ADRIANOPLE AND CONSTANTINOPLE.*

Adrianople is situated close to the junction of the Maritza and Tundga rivers. Both run through the town; the former for a little, and the latter for a considerable distance. In that part of its course, the Tundga makes a loop-like turn through the outskirts of the town, so that, in passing through Adrianople, entering at the west and leaving at the south-east, the Tundga is crossed twice. The town has a very picturesque site. It occupies the end of the hill-ridge which bounds the Tundga valley on the left, and for some distance extends into that valley. Looked at from all sides, except that towards the hill on which it stands, it is seen to rise up gently out of the low ground to the summit of the hill, and there it is crowned by one of the finest mosques in Turkey—that of Sultan Selim. Almost every house has a large garden, in which grow tall fruit trees. These trees give to the town the appearance of a large orchard: only the highest houses and minarets appear above the green foliage; and in autumn when the leaves are fading, the changes in colour produce very fine effects. Adrianople, like most other Turkish towns, appears beautiful when viewed from a distance, but the scene is unpleasantly changed when it is entered. Its main street is almost without footpaths, only broad enough to allow two vehicles to pass, and has in it holes, all but large and deep enough to overturn a carriage. The other streets are narrower and rougher. Most of the houses, except the government

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* Only the part of the Paper relating to Adrianople is printed.

buildings and the mosques, are built of mud, and are of one storey high. What Byron, in Childe Harold's Pilgrimage, says of Lisbon is very applicable to Turkish towns—

"But whoso entereth within this town,
That, sheening far, celestial seems to be,
Disconsolate will wander up and down,
'Mid many things unsightly to strange ee;
For hut and palace show like filthily."

Besides the hill-ridge on which the town is situated, and which runs nearly north, fixing the course of the Tundga, there is another ridge, running in a south-westerly direction, and bounding the valley of the Maritza. On these ridges were placed nearly all the forts for the defence of the town, 25 or 26 in number. Adrianople was thus protected by fortifications on all sides except the east, and on that side the two rivers run before their junction. Beyond the rivers is an extensive plain, in which is situated the railway station, about two miles from the town. There was also a solitary fort there.

We shall begin our tour through Adrianople at the Stafford House Hospital, because for a starting-point it was well situated, and it was the chief scene of my labour. But, in our look-in here, I shall treat your strictly as unprofessional visitors; I shall uncover no wounds, nor ask you to look at any operations.

This place was formerly used as a barrack, and was probably built when the greatness of the Ottoman Empire centered in Adrianople. Its construction is that of nearly all Turkish barracks—an extensive two-storeyed building, enclosing a quadrangular piece of ground. The internal arrangement is simple, and is the same in the upper and lower storeys,—the inner third (the side next the enclosed ground) of the building, being occupied by a continuous corridor, and the outer two-thirds by different apartments opening into the corridor. The doors of the hospital open into the enclosed space of ground, from which four gates, one in each side of the quadrangle, give exit. Some years ago almost three-fourths of the original building were maliciously destroyed by fire, and now stand in bare ruin; and what remained stood long empty, until in the beginning of last August it was opened as an hospital.

Part of this hospital was under the charge of Turkish medical men, and part under the Stafford House surgeons. In the former part there were 1,700 beds, and in the latter 300. The whole hospital, with regard to the food and clothing of the patients, was under the administration of a Turkish official.

The wounded treated here came chiefly from Shipka and Plevna; but first we had the wounded at the battle of Yeni-Zaghra, where, in the end of July, the army of Raouf Pasha was cut to pieces by the Russians under general Gourko. The wounded arrived in companies of 500 and 600, and were distributed among the different hospitals. It often happened that some of these men had not had their wounds dressed for more than fourteen days, and had had little to eat or drink, having passed that time on a journey in bullock waggons and railway trucks; and it is impossible to conceive, without seeing it, the filthy and miserable state into which they were reduced. After remaining in hospital a longer or shorter time, according to the more or less serious nature of their wounds, they were sent off in large lots to Constantinople. They were nearly always most willing to leave, and when the surgeon entered the ward to write down those who were to go, at every bed he would receive a respectful salam, and hear the exclamation: "Stamboul, Effendi, Ben ee"! "Constantinople, sir, I am well"! We were all fond of our patients; and they were obedient and respectful to us, and grateful for our services. During the whole time the hospital existed I never heard a patient make a complaint to any of the numerous Turkish officials by whom they were visited. On the other hand, the idea of superiority of the English to the Turkish surgeons occupied the minds of the soldiers generally; and when a lot of wounded arrived at the hospital, they were most eager, if possible, to get under the care of the "*Inglese haikims.*"

Turkish patients object to surgical operations more than Europeans do, principally, I believe, on account of their firm belief in Fate, and the alluring character given to life beyond the grave by the Mohammedan religion. Still, though I have seen some hold out against operations to the last, and sink down contentedly and even joyfully; in most the natural love of natural life, even without an arm or a leg, overcame their dependence in Fate and the allurements of a pleasingly-painted Heaven.

Our patients were mostly Turks and Arabs; and, with regard to the power of enduring pain, the two races differ much. I have seen a Turk bear the amputation of his foot without taking chloroform, and almost without uttering a moan; and I have seen an Arab become almost frantic from the pain of removing his dressings.

The wounds were as a rule caused by bullets and pieces of shell; there were few bayonet or sabre wounds.

There were some curious cases of wounding. One was that of a little Bashi-Bazouk, wounded at Yeni-Zaghra—first his left arm was broken by a bullet, then he was attacked by a Cossack, and, after having received two or three sabre-cuts on the head, he caught hold of the blade of his assailant's sword, in the withdrawal of which his right hand was almost cut in two, and then he received a parting-cut which almost severed his left arm from the body. This man left the hospital for his native country almost cured. There was another case in which the bullet passed across the front of a man's chest—some places below, and some places outside the skin—entering and emerging several times; another in which a bullet traversed a man's face from temple to temple, carrying away both eyes; and another in which a man was shot through the arm by a bullet which killed the soldier in front of him. I know of two cases of remarkable protection from bullets, in one case by a book and the other by a piece of paper. Every Turk wears a broad woollen girdle wound several times round his body, and between its folds he carries the most precious part of his stores. During an attack on the Shipka Pass, a Turkish soldier, who was carrying his Koran in his girdle, was struck by a bullet, which passed right through the book and scarcely wounded his body. At Plevna a *téz kérè*, or passport, carried in the same manner, was the means of saving another soldier's life. This man was wounded, but not deeply.

The staple food of the patients was a dish called *piloff*, and consisting of boiled rice and mutton. This was served three times a day; besides which, each man was allowed one or two extras, as tobacco, a plate of boiled vegetables, a small beefsteak, or some milk. They were very fond of water-melons, and in the season were constantly asking for *karpuz*, that being the Turkish name for that fruit.

In hospital the soldiers passed their time in making and smoking cigarettes, in needle-work, in card-playing, and in story-telling—the great source of entertainment among the Turks. Three times a week the town band came and performed in the Hospital Square; and when opposite the English part it played the British Anthem. Once or twice a week those who were able went to the *hammam*, or baths.

The hospital was visited once a fortnight or so by the governor of the town; and every high Turkish official who passed through generally called. The visitors went round all the patients, and asked them if they were satisfied with their treatment, or had any complaints to make.

When a patient died his body was carried to the dead-house, where by priests it was washed in soap-and-water, the beard trimmed, and the nails cut. It was then wrapped in a linen cloth, and placed on a bier with the head towards the south; and a priest, standing facing the east, and supported by the corps of men who buried the dead, pronounced the burial service over it. The body was then carried out and laid in the grave, without a coffin, and with the head towards the south.

The graves were dug about three feet deep, and the side towards the east made a little lower than the other. Along the lower side the body was laid, and boards of the proper length, standing on their ends, were placed so as to slant over the body, from the bottom of the unoccupied side to the top of the other. The half of the grave shut off from the body by the boards, was then filled with earth, and a mound made on the top. Thus the body lies in a place, otherwise unoccupied, which takes up half the grave, and reaches to the level of the surface of the surrounding ground. This space is left in the graves on account of a belief the orthodox Mohammedans have in a sepulchral examination of the dead. "When a corpse is laid in the grave," they say, "he is received by an angel, who gives him notice of the coming of two examiners; who are two black livid angels of a terrible appearance, named *Monkir* and *Nakir*. These order the dead person to sit upright, and examine him in his faith concerning the unity of God and the mission of Mohammed; and if he answers rightly, they suffer his body to rest in peace, and it is refreshed by the air of Paradise; but if not, they beat him on the temples with iron maces till he roars out for anguish, so loud, that he is heard by all from east to west, except men and genii." The manner of burying, which I have described, may be very convenient for a theological post-mortem examination, but it must have bad sanitary effects, as the gases of decomposition are separated from the atmosphere by at most two or three inches of earth.

In connection with this part of the subject, I shall say something of the organizations which existed for the relief of the Turkish wounded in the late war. First, there was the army medical department, which professed to provide surgeons in the field, and hospitals in the rear. For field service, a physician, an operating and an assistant surgeon, with a case of medicines and a case of instruments, were attached to each battalion of 1000 men. But battalions were often without their physicians or surgeons, and these were often without their medicines and instruments.

The Turkish hospital service was a more efficient organization. The great imperfection of the Turkish army medical arrangements, was the want of an organised system for transporting the wounded from the battle-fields to the hospitals. That was done by pack-horses or bullock-waggons, which were requisitioned from the district, or which were returning empty after having brought up supplies. They conveyed the wounded to the nearest hospital or railway station, and their journeys often extended over many days, during which time the patients were imperfectly fed, and were under little or no medical care. The medical men employed in this service were principally natives—

Turks, Armenians, and Greeks; but there were a good many Germans and some English. Many of these native doctors have had a fair scientific education and training at the medical school in Constantinople; but many also have had no such education. The latter commenced their careers as attendants or barbers in the hospitals, and were afterwards made dressers, then assistant surgeons and surgeons. On account of these two methods of educating Turkish medical men, some are passable, and a great many are very bad; and the results of their work, which I have seen, were what one would naturally expect.

Next, there was the Red Crescent Society—a Turkish society under the protection of the Geneva Convention. A good deal of money was collected by the members of this society: they spent much to no purpose, and made a great noise about what they were trying to do. Their chief purpose was to remedy the defect of the army medical service, and establish a proper transport system from the front to the rear. They engaged a large staff of surgeons and multitudes of attendants; they fitted out most completely ambulance waggons for carrying wounded across the country; and they built an ambulance railway train, with all conceivable conveniences. But, most of their road ambulances broke up and came to untimely ends; the few which did get into work did little; and the railway ambulance, their chief work, only made one journey.

There was the Red Cross Society, which had only a few surgeons engaged. Then there was the English Society of the Stafford House, which was the means of affording much relief to the Turkish wounded; but whose members, I am persuaded, have been little thanked by the Government. This society was first formed to send medicines to the Turkish wounded; but when a report was spread that the Turkish physicians and surgeons were ignorant, and unacquainted with the strengths of British medicines, and that they would poison more than they would cure, Lord Blantyre, a member of the committee, at his own expense sent a number of surgeons. Subsequently, the committee also sent out surgeons, who co-operated with those sent by Lord Blantyre. The Stafford House Committee sent surgeons to the field, established hospitals towards the rear, and organised transport systems.

Leaving the hospital, we see before us, stretching towards the town, a large piece of ground covered by a fine green sward. This was the parade ground, and seldom was it for a day unused by troops for drill or reviews. Here also during the fighting at Shipka, the regiments were mobilised before being sent forward. Here also, I imagine, Mohammed II. reviewed his grand army before setting out for the capture of Constantinople.

The strength and the glory of the Turkish army were in its infantry. But the idea which I formerly held, that pomp and a certain amount of splendid show were always connected with soldiers, was quickly lost when first I saw the Moslem troops. The average Turkish infantry soldier is a taller and larger-framed man than the average English foot soldier: but in Turkey, not as in England, the infantry regiments contain bigger men than the cavalry regiments.

The infantry soldier wears a tunic and trousers made of a coarse, dark-blue, native cloth. His tunic is a bad imitation of the English soldier's tunic, and his trousers are generally so short that they leave uncovered the tops of his stockings, and a piece of *cutis humana* of his legs. His outfit is completed by a large unblocked, scarlet fez, an unpolished leather belt, and a pair of coarse leather boots, made for lacing, but seldom laced, with brown tops never stained by Day and Martin, but covered by an abundant alluvial deposit. His arms are a rifle and a bayonet, and he generally carries his cartridges in little receptacles sewn across the breast of his tunic.

It was most interesting to watch these men on the parade ground. You would be struck by the serious manner, habitual to the Turks, in which they went through the different parts of the drill ; but often you would be disgusted by displays of Turkish authority ; for, when a soldier makes a mistake in his drill, the officer comes forward and cuffs the offender's ears. I had previously seen a good many reviews of different soldiers, and could never help thinking that the men I saw were there principally in order to produce an imposing appearance ; but when I saw the plain and untidy Turkish soldier, with his solemn air, at once I could feel that these men followed the fearful trade of war.

It was the cavalry which brought most disgrace on the Turkish army ; for in it were most of the irregulars or Bashi-bazouks. There were few regular Turkish cavalry. Their uniform resembles that of the infantry, and they are armed with a sword and Winchester rifle. The Arab cavalry were numerous. They wear mostly light blue jackets and pantaloons, with white trimmings, and their heads are covered with a many-coloured silk handkerchief, which falls over their shoulders, and is secured by a large cord of camel's hair wound round their heads. They are well-mounted, and have their horses profusely decorated. These men are pretty well under discipline, and are as well conducted as the regular troops.

The Circassians made up another division of the Turkish irregular cavalry, and exceeded all the others in cruel excesses of conduct. They were but armed robbers and assassins, and made the Christian and Mussulman inhabitants alike their victims. They have fair hair and a narrow face, with a cruelly cunning expression. They wear a coat which fits the waist closely, and then hangs loosely to below the knees, and a sheepskin cap with cloth top. They are armed with a large, pointed, two-edged knife, or a sword, and a rifle ; and are always mounted upon the best horses that they can steal. When the Circassians were given Winchester rifles by the Government, as they went towards the front in the train, they amused themselves by shooting at the birds on the telegraph wires, and they often broke the wires, and interrupted telegraphic communication. They even went so far as to shoot at, and kill, several Bulgarians who were working in the country they passed through ; and at the camp at Shipka they used their rifles so freely and carelessly, that a number of soldiers were shot, and a general order had to be given, forbidding the unnecessary discharging of rifles. The Circassians were a terror to both the Mohammedan and

Christian inhabitants of the country: they followed the retreat of the Turkish army to Constantinople, which took place after the disasters in the north of Roumelia; they sacked and burned most villages in their course, up to 50 or 60 miles of the capital; and they stole and collected the cattle and horses of the country as they came along, and were to be seen arriving every day with large herds of cattle and strings of horses. The Circassian rode the first horse in the string, to its tail a second horse was tied, and so on for five or six.

Leaving the parade ground, we pass by the old palace, the first residence of the Sultans in Europe. It was held in great veneration by the Turks, and in it was a chamber into which no one was allowed to enter. Latterly the palace was converted into an ammunition magazine, and, on the approach of the Russians to Adrianople, the Turks, in destroying the military stores it contained, burned the whole palace to the ground. I believe it was the intention of the Turkish authorities to burn this palace with the stores, to prevent it falling into the hands of the Muscov-Giaours. It was formerly surrounded by fine gardens and parks, and there are still there some of the finest trees I have seen in Turkey.

Before entering the town we cross a long viaduct over low ground, and a bridge across the Tundga. In passing through Turkey we see many signs of national decay, and few of improvement, and nowhere is that state of matters more evident than in the place to which we have got. All round we see the evidences of former greatness, the deserted palace, the many ruins of fine buildings, and the splendid trees—the only survivors in the general decay. Many of these old ruins were quite mines of building materials, which were utilised in the construction of the recent fortifications. And as I saw them being quarried down and carried away, I could not help feeling pleased, through a sort of sympathy with the old walls, which were grand and strong when their old owners were powerful; which had seen the days of Amurath and Bayazid, and the grand array of Mohammed II. starting to conquer Constantinople; which had crumbled into ruins through the failing energies of their descendants; but which were now revived again as it were, to save the departing national existence.

The viaduct was well constructed, and made for an object which would never enter the head of a modern Turk—to have a good road. Its pavement is now out of order, its walls are falling; and rather than repair it, carriages and arabas were driven across the low ground, often up to the naves in mud, and over inequalities which threatened their overthrow. The Turks seem to be acting as if they thought their stay in the country would be short; nothing is done except that which cannot be done without; and what is done is done in a most makeshift manner.

The bridge which we now cross spans the river by three or five arches. The Turkish arches resemble the Gothic; and in a bridge where there are more than one, that in the centre is the highest, and the others decrease in size towards the sides. This arrangement gives to the bridge as a whole an arched form. On the top of every bridge at one side a little covered balcony with a seat is built, and at the opposite an open balcony. These balconies are the resorts of beggars, and the resting places of travellers.

We will now enter the town, pass along the principal street, and I shall introduce you to some of those whom we shall meet there. The streets of a Turkish town are filled with a motley crowd—Turks, Armenians, Greeks, Hebrews, Bulgarians, and Europeans. There are men there from every nation under heaven, wearing every costume, and speaking every tongue.

The male Turks of the upper classes, when they are not dressed *à la Franka*, wear a short jacket and baggy trousers of a blue material. The free shape of the latter garment allows them to assume their characteristic sitting posture without straining its seams. They also wear a flowing gown, or *kaput*, which descends almost to their feet; their heads are arrayed in fez and turban; round their waists are scarlet girdles, and on their feet shoes with narrow and up-turned toes. The clothing of the lower classes is made of coarse, brown cloth. The dimensions of their trousers are only great to the knee, and they dispense with the *kaput*.

The women are the characteristic feature in a Turkish community. They generally walk together in little companies of three or four, and as a rule the men pass them by without looking at them. They all wear the *yeshmack* or veil, which covers the head and face, only leaving a little triangular aperture through which the eyes and the nose are seen.

Some women wear their veils much more closely than others: the old are, as a rule, I think, more careful than the young to keep themselves concealed. When on a journey they bind coloured handkerchiefs round their foreheads to secure their *yeshmacks*. A large cloak without seam throughout, and of a uniform colour, which may be pink, green, blue, white, or black, conceals them from the neck to the feet. Their boots are shaped like those of the men, and are often coloured yellow. What I have described is the exterior dress of a Turkish woman, the dress in which she must appear to all but members of her own household; but there are some opportunities, even in the streets, of observing what a Turkish woman wears under her cloak. That garment occasionally becomes deranged, and is righted by the wearer catching a side in each hand, opening, raising up her arms and then folding them across her chest. This action discovers a pair of wide trousers and a short quilted jacket, both generally made of coloured cotton. A rich Turkish woman wearing a snow-white *yeshmack*, a fine green silk *ferrajé*, and a pair of yellow shoes, looks, I think, very well; but a poor woman in a soiled *yeshmack*, a faded and mud-stained *ferrajé*, and coarse leather shoes, looks very badly.

The Turkish women are, as a rule, tall and slightly made. They have deep dark eyes, and

> "Her eye's dark charm 'twere vain to tell,
> But gaze on that of the gazelle,
> It will assist thy fancy well;"

a white, soft, velvety-looking skin, due to the frequent use of the bath, and protection from bright light; and a voice of very pleasant tone,—it has the tone of a girl's voice with the mellowness of a woman's. They are extremely fond of shopping, and are constantly thronging the *curshis* or bazaars, chattering and talking to the shopmen.

About the Turkish women at home, I must ask to be allowed to give what a lady traveller who had the privilege of entering a harem, says:—"Their habits are, generally speaking, most luxurious and indolent, and if I except their custom of early rising, which, did they occupy themselves in any useful manner, would be highly commendable; but as they only add by that means two or three hours of ennui to each day, I am at a loss how to classify it. Their time is spent in dressing themselves, and varying the position of their ornaments, in the bath, and in sleep, which they appear to have as entirely at their command as a draught of water; in winter they have but to nestle under the coverings of the tundour, and in summer to bury themselves among their cushions, and in five minutes they are in the land of dreams. Indeed, so extraordinarily are they gifted in this respect, that they not unfrequently engage their guests to a nap, with the same sangfroid with which a European lady would invite her friends to take a walk. If, as we are prone to believe, freedom be happiness, then are the Turkish women the happiest, for they are the freest individuals in the empire. It is the fashion in Europe to pity the women of the East, but it is ignorance of their real position alone which can engender so misplaced an exhibition of sentiment. They are permitted to expostulate, to argue, even to insist, on any point in which they may feel an interest; nor does an Osmanli husband ever resent the expressions of his wife; it is, on the contrary, part and parcel of his philosophy to bear the storm of words unmoved, and the most emphatic and passionate oration of the inmates of his harem seldom produces more than the trite, Bakallum—we shall see. It is also a fact that although a Turk has an undoubted right to enter the apartments of his wives at all hours, it is a privilege of which he seldom, I may say never, avails himself. Should he see slippers at the foot of the stairs, he cannot on any pretence intrude himself in the harem; it is a liberty that every woman in the empire would resent. The instances are rare, save among the higher ranks, in which a Turk becomes the husband of two wives. He usually marries a woman of his own rank, after which, should he resolve on increasing his household, he purchases slaves from Circassia and Georgia, who are termed *odaliques*, and who, however they may succeed in superseding the *buyuk hanoum*, or head of the harem, in his affection, are nevertheless subordinate persons in the household, bound to obey her bidding, to pay her the greatest respect, and to look up to her as a superior."

I must pass by without comment the Armenians, the Jews, and the Greeks, to the Bulgarians—the hewers of wood and the drawers of water. In Turkey at the top of the social system is the Turk, and at the bottom the poor Bulgarian.

The Bulgarians are, as a rule, tall and erect; their features are well defined and good (not at all like what I have seen represented in English illustrated journals); the expression of their faces is pleasing, but indicates little intelligence; their hair which is dark brown, is mostly worn plaited by both sexes; and the men, who have generally long mustachios and short whiskers and beard, are as a rule more handsome than the women.

The men wear trousers and jackets made of coarse brown woollen cloth of their own manufacture; on their heads they wear a coarse dark turban or a sheepskin cap; and their feet they wrap in coarse cloth or sheepskin. The women also wear trousers, but their characteristic piece of attire is a garment with a moderately close-fitting body and loose skirts. It has no arrangement to facilitate its putting on or taking off, so that the wearer requires the aid of an assistant to get in and out of it. They are very fond of jewellery, and of decorating their heads gaily—but such fondnesses are possessed by the female sex, wherever found.

These people were kept in a servile condition by the Turks. I cannot now think of a Bulgarian without mentally associating him with the oxen, his constant companions. At Adrianople they were nearly always to be seen leading the oxen in the *arabas* or wagons; going in companies to work in the forts; or coming into town with the produce of the fields. Most of the transporting of stores and wounded men to and from the railway station, was done by the requisitioned bullocks and *arabas* of Bulgarians. I have seen a Turkish soldier come up to a Bulgarian who was going along the street with his ox-wagon, seize hold of the oxen, and pushing the owner out of the way, lead them off to work for the Government. The fortifications round Adrianople were made by the Bulgarians: they dug and wheeled under the charge of Turkish taskmasters, who walked about with sticks in their hands for application to lazy Bulgarian shoulders.

Not only were they worked as slaves, but they were subject to many acts of cruelty. When I went first to Adrianople, about daybreak two or three times a week from twenty to thirty Bulgarians were hanged. These men had been arrested in the district, and sent bound to Adrianople. When sent by rail all the prisoners in each compartment were tied together by ropes, and at the station a guard of soldiers took charge of them and marched them off to the prison. They were charged with conspiracy and other crimes, and sometimes the evidence against them was slight. On the mornings of their executions they were taken out in companies by a guard of soldiers, and one or two hanged at the most public places along the principal streets. They were suspended by small ropes, from rude wooden tripods, or the cross-bars of quadropods,—from these generally two or three,—or from wooden brackets nailed against door-posts. The scaffolds were small stools or blocks of wood on which the criminals stood until the ropes were fixed round their necks, when they were pulled from beneath them. Round the neck of each criminal a placard was hung, stating for what he was executed.

The *chawush*, or sergeant, who had charge of these executions, generally turned them to his profit: he would say to a shopkeeper whose shop was near where an execution was to take place, "I am going to hang a Bulgarian here; how much will you give, and I won't put up my fixtures before your door or on your door-post?" The shopkeeper would then offer him what he could afford. He would then go to another shop, and give the same information, and ask the same question of its owner, who, if unable to give more *bakshish* than the first, would have his door made the scene of the execution.

At first the bodies were allowed to hang until sunset, when a cart went round and collected them; but afterwards, through the influence of the foreign consuls, they were taken down a few hours after execution. Ultimately, because Adrianople was too public a place, the executions were not done there, but the criminals were taken off by the morning trains, chained together by the necks, and executed in the neighbouring villages.

Once I saw two Turks run off with the clothing of a Bulgarian, who had been bathing in the river, and when he ran after and caught one of the two practical jokers to recover his clothes, one of the Turks struck him several times in the face, only stopping when he saw a stranger approaching. I have seen the Turkish children taunting and insulting these people as they walked along the streets.

The Bulgarians are the chief husbandmen in Turkey. As a rule they are industrious, and there is a thrifty appearance about their villages, which is not seen about those of the Turks. They are, however, servile, cruel, and very inhospitable, and will refuse to sell provisions to travellers, or say they have none.

In agriculture, the draught work is done by oxen. These animals are of two kinds, one, a white ox of the ordinary size, and the other a larger black buffalo ox. These buffalo oxen have an intense love of bathing in water or mud, and they often indulge this desire with evil consequences to their load. One hot day in summer, a grave old Turk, with his wives and children, was driving two of these animals in a wagon along the road; suddenly the oxen espied a pond of water by the wayside; they ran towards it; and, in spite of reins and goad, entered it, nor stopped till nothing but their heads were visible, when they calmly gave themselves up to enjoyment, regardless of the state of matters behind them.

The Turkish wagon, or *araba*, as it is called, is a four-wheeled wooden vehicle, in the construction of which poles instead of boards are used. The oxen are attached to it by a pole, connected at one end to the araba, and carrying at the other two cross-bars for the necks of the oxen. These oxen and arabas are not only used in agriculture, but they were the only means of transport beyond the railway stations during the recent war. The Turkish Government have a great number of these arabas, which are under the charge of soldiers, and it is interesting to observe how differently a Turk and Bulgarian drive. The Turk sits in the araba, and urges on his oxen with the goad; whereas the Bulgarian walks in front of his oxen. If you are driving in a more quickly-moving vehicle, and happen to overtake in a narrow way one of these arabas driven by a Turk, he will scarcely deign to notice your presence; but a Bulgarian under like circumstances will at once pull his oxen to the side, and stop until you pass.

The Turkish soil is deep, loose, and very fertile; but little of the ground is under cultivation. Round a village or town for a short radius crops are raised, but beyond that the ground lies as nature left it, producing only pasturage for immense flocks of sheep and herds of cattle.

The soil is turned up by a wooden plough drawn by two oxen. It is the same implement that is represented in illustrated Bibles as having been used by the Children of Israel. I have seen a little fellow of about nine years of age, hold the plough admirably, it is so light, the oxen are so docile, while the soil is loose.

Fine grapes are grown, and a little very good wine is made, where there are Christian inhabitants; but the Mohammedan religion forbids the using or selling of wine. This wine is pure and cheap; it is a red wine, not quite so deep in colour as claret, but sweeter, and with age it becomes brighter and pleasanter to the taste.

Maize, rice, wheat, and barley, are also grown. The grain is thrashed in the ancient manner, by treading it out by oxen. A dry and hard piece of ground is chosen for the threshing-floor; the sheaves are spread over it, and the corn is trodden out by two oxen yoked to an implement like a sleigh, on which the driver stands.

As we pass along the street we get a view of Turkish commercial life. The shops, which have the same construction in the streets as in the *curshis* or bazaars, are small, and have only one little square or triangular apartment. The whole front is open ; on the other sides, in shelves or suspended, are the articles for sale ; while the floor, which is a few feet higher than the street, is covered with a piece of carpet, and occupied by the owner, and it may be by his assistants, sitting cross-legged. It is impossible for a customer to enter a Turkish shop; he stands on the street and negociates with the merchant, who is sitting at the same time on his counter or his floor.

If the merchant is also a tradesman, he works at his handicraft in the same place, and as one passes along he sees the *terzi*, or tailor, sitting among garments in the crude and perfect condition ; the *chizmaji*, or shoemaker, hammering his leather and sewing his shoes ; and the *ekmekji*, or baker, who takes away the back part of his floor, standing attending his oven and kneading his dough on his little counter. There is also the shop of the scribe, who, sitting on a mat, his papers laid on one hand, and his pen in the other, writes letters from the dictation of his customers, generally women.

The *curshis*, or bazaars, are merely covered streets with shops, such as I have described. At night the *curshis* are closed, and during the day every person who enters is supposed to want something. Therefore as one walks through them he is constantly greeted by the Turkish, " *Nestursen Effendi* ?" the Italian, " *Cosa volete Signore* ?" the French, " *Qu'est que vous-voulez*, *monsieur* ?" and perhaps the English, " What do you want, sir ?" In offering their wares for sale, the merchants ask prices three or four times the proper values ; and if they receive what they ask they are much troubled that they did not ask more :—they are still like the old Jew to whom Aladdin sold his silver dishes.

The greater part of the commerce of the country is in the hands of the Greeks.

" Still to the neighbouring ports they waft
Proverbial wiles, and native craft ;
In this the subtle Greek is found,
In this, and this alone, renowned."

These few lines from Lord Byron's Giaour describe well the general character of the Greeks in Turkey.

We shall now take a look at a Turkish Mosque, and at Adrianople there were many. On the highest site in the town stands the Sultan Selim, a splendid mosque with four minarets. There is another mosque with three minarets each of which is built on a different style; one is spirally fluted, and is, I have been told, the highest minaret in Turkey; another is covered with red and white diamond-shaped patches, and the third is plain. A simple mosque is a square building covered by a dome, and having a minaret at one corner. But a mosque may be made a very complex building, and have one, two, three, or four minarets. The minaret is a column of uniform diameter, with a pointed capital, and is encircled, according to its height, by one, two, or three balconies. A spiral stair runs up this minaret to the balcony or balconies.

The foundation stone of the Mohammedan religion—which is the religion of the Turks—is that there is but one God, and that Mohammed is his prophet. The four heads under which the practice of their religion is comprehended, are:—1, Prayer, under which are included those washings and purifications which are necessary preparations before prayer; 2, Almsgiving; 3, Fasting; 4, Pilgrimages.

They are commanded to pray five times each day: 1, in the morning before sunrise; 2, when the noon is passed, and the sun begins to decline from the meridian; 3, in the afternoon, before sunset; 4, in the evening, after sunset, and before the day is shut in; 5, after the day is shut in, and before the first watch of the night. When the appointed hour comes, the *muzzins*, or priests, ascend the minarets, and call the people to prayer. Many come to the mosques, and on bended knees, with their faces towards Mecca, follow the priest in prayer; others in their houses spread their carpets in their accustomed places; while others in the fields kneel down on the grass to pay their homage to Allah. In the mosques, a niche marks the direction of Mecca, towards which the worshippers turn their faces; in their houses they have a certain corner where they kneel ; and in the fields, where there was no particular object to mark the proper direction towards which to look, I have seen them set up a stone or a water jug. During prayer, a Mohammedan often brings his hand over his face, and prostrates himself to the ground several times. Women are compelled to pray at home, or in the mosques when the men are not there ; and such an opportunity is afforded once a week.

With regard to washings : there are two kinds—complete and partial. The former is required on certain not very frequent occasions ; but the latter has to be performed each time before prayer. As water is not always convenient, the faithful are allowed to use sand instead ; and often before the time of prayer, men are to be seen walking along the streets, rubbing their hands on the walls and then on their faces. This liberty to use sand for water, when the latter is not easily to be got, is often, through laziness, abused, especially by the lower ranks of the Turks, who thus, instead of being extraordinarily clean, are often extraordinarily filthy.

About almsgiving I shall say nothing, but that it is of two kinds, legal and voluntary : the former cannot be dispensed with, but the latter is left to the free-will of the giver.

The third point in their religious practice is fasting. For this purpose one whole month, the month of Ramazan, is set apart, and is most strictly observed. From sunrise to sunset they neither eat, drink, nor sleep, and, what I think is to Turks the greatest self-denial, they don't smoke. Some even are so strict that they will not smell a perfume, or voluntarily swallow their spittle. As this Turkish year is the lunar year, this month passes through the different seasons in the course of 33 years, and when it falls in the summer, as it did last year, its observance is most trying. Passing along the streets towards the close of the day, you see the people languid and listless, business is stopped in the shops, and the merchants are sitting idly yawning. But no sooner have the *muzzins* from the minarets announced the close of day, by calling to sunset prayers, than the scene is suddenly changed, and everywhere is life and excitement. Cannons proclaim the nightly feast; the minarets are illuminated; the streets are thronged with the sellers of sweetmeats and fruits; the shops of the bakers are crowded; the women are buying oil for their lamps; and the streets are full of hurrying people. The feasting is allowed until daybreak, and the time to prepare the last meal is announced by the beating of a drum through the streets. Soldiers, those who are on journeys, and those who are sick, are exempted from the observance of this fast. This month is a notable epoch with the Turks, and from it they often calculate the time of an event. Thus, when we asked a soldier when he was wounded, he would say, such a day of Ramazan, or so many days before or after it.

The pilgrimages to Mecca are commanded as important observances, and all who can are required to perform them.

The Koran of Mohammed forbids the drinking of wine or strong drink, and this command is generally observed by the lower ranks of the Turks, especially those dwelling in country villages; but I cannot say the same for the upper classes, especially those who have become somewhat Europeanised. Most of the common soldiers would not drink wine or brandy, even when prescribed for them; some would, and a few even asked for it; but most of the officers drank it readily. I remember that on the morning on which we had to evacuate Adrianople, our patients had had little food or drink, and when we offered to serve them with wine they almost to a man refused it. The Turks also consider the pig an unclean animal, and do not eat its flesh.

Friday is the weekly holy day that the Turks observe. On that day they go to pray in the mosques, and close their shops, some for the whole day, and some for part of it. At Adrianople, where there was nearly an equal number of Turks, Jews, and Christians, the observing of three days in each week was noticeable. On Friday the shops of the Turks in the streets and *curshis* were closed; on Saturday those of the Jews; on Sunday those of the Christians; and on their proper day the members of each sect put on their holiday attire.

The Turks have two annual feasts—the Sheker, and the Qurban

Byram. The former, the Sheker, or Sugar Byram, commences at the close of the fast of Ramazan, and lasts three days ; and the latter, the Qurban or Sacrifice Byram, commences on the night the sacrifices are slain at Mecca. On that night each head of a family sacrifices a sheep or other animal, according to his ability. On the previous day the animal is decorated, and then children are often to be observed leading about a sheep painted many colours, and having its horns gilded. Both of these fasts last three days, and are ushered in each evening at sunset by the firing of cannon. The minarets are illuminated at night, not only, as during the Ramazan, with circular rows of lamps round the balconies, but the shafts are also surrounded by perpendicular rows, and from one minaret to another lamps are hung, arranged to form mottoes and names in Turkish characters. At night the effect of these illuminations is very fine : when only the balconies are lighted, at a distance, the town seems covered with burning circles, and when the more extensive illuminations occur, there stand up complete minarets of fire, while hanging among them are seen crescents and stars, and blazing brightest the great name of Allah. The illuminations are produced by little lamps in glass lanterns. The lamps consist of little glass vessels holding oil, or oil floating on water, in which a little piece of tow or wick is suspended.

During these feasts the Turks wear their gayest clothes, give presents to their children, and make and receive visits from morning until night.

5th February, 1878.

The President, Robert Young, Esq., C.E., in the Chair.

Abstract of a Paper read by William Gray, Esq., M.R.I.A., on

THE ANTIQUITY OF MAN GEOLOGICALLY CONSIDERED.

[This Abstract is printed last, in consequence of the MS. not being received in time to print it in its place.]

Mr. Gray commenced by showing that the history of man as head of the biological world is intimately connected with the history of the various other forms of animal life, which life-history is inseparable from the physical history of the globe. Throughout the enormous period necessary for the accumulation of fourteen miles thick of the earth's strata, organic life existed on the globe, first manifested in lowly forms and progressing by an unbroken stream, gathering strength with every succeeding age, as species were added to species in the greatest variety, until the first appearance of man;—the order of progress from the simpler to the more complex forms being in the order of time.

Of the many thousands of species which have thus appeared from time to time, the majority have died out and become extinct, a comparative few only surviving until man. Of those that have become extinct, the terms of existence were extremely variable. Some lived through many geological periods; some are found only in one, and many are confined to very limited zones. As each species appeared in time, others were attaining their maximum development, and others again were drawing nigh to their final extinction. So also, when man appeared, he found a considerable number of species in every stage of the allotted terms of their existence; hence it is that so many have since died out, and that the remains of now extinct animals are so often found with the earliest remains of man.

Whatever may have been the anticipations of scientific men as to the existence of man during past geological ages, all the evidence that has been accumulated up to the present, including the result of most careful and thorough investigations in various parts of the world, goes to prove that man was the last created being, and that the evidence of his first appearance is found only in connexion with the latest superficial deposits.

Mr. Gray fully described the sequence of the later Tertiary deposits and the subsequent glacial phenomena, illustrating his subject by reference to examples in our own locality, and proved the comparatively modern date of the deposits in which alone the earliet evidence of man is found. Those evidences consist chiefly of tools, implements, and weapons: indications of that inheritance of labour and strife to which man was born.

Mr. Gray then described the various forms of implements belonging to the so-called Stone, Bronze, and Iron ages, dwelling chiefly upon the Stone age, and showing the wide distribution and uniform character of the stone implements all over the world. Thus, if we compare our local worked flints with those of other countries, we find that the flakes from the Larne gravels and from the Antrim and Down sand-dunes, cannot be distinguished from the flakes found in the Swiss lake dwellings; and the flint scrapers from the Ormeau Cricket Ground cannot be distinguished from the scrapers from the ossiferous caverns of France.

Having described the various sources from which stone implements and other evidences of early mankind are obtained, Mr. Gray summarised the facts, going backwards in the order of time.

During the Surface period we find polished stone implements, pottery, and the remains of several industrial arts, together with domestic animals, but no extinct species.

In the Lake dwellings we have polished stone implements, rude pottery, spinning, weaving, the cultivation of wheat and other cereals, with the remains of domestic animals.

In the Kitchen heaps we find a few polished stone implements, rude pottery, a few spindle-whorls, but no domestic animals.

In the Caverns—no polished implements—all are roughly chipped; a trace only of spinning, and very little pottery. No domestic animals, but several extinct species.

In the Drift Gravels the only evidence of man found consists of rudely chipped implements of special forms, and they are associated with the remains of several species of extinct animals.

We have in this summary a series of facts, showing a gradual advance, which by no means demands the extended periods too often assigned to it.

Great importance has been attached to the large number of extinct animals found in connexion with the earliest evidence of man; assuming that this proves that very marked climatic changes must have occurred since then; but climate alone could not account for such a variety of species. The animals must have migrated from opposite regions, or their remains may have been washed from deposits of different periods, for they are usually mixed confusedly together in such a manner as can only be accounted for by the agency of water.

The most remarkable of these ancient animals are the Mammoth and the Rhinoceros, and remains of those very animals are still found in large quantities in the ice valleys of Siberia, being evidence of animal life in those regions many thousand years before man's visit. Now, we have positive proof of the existence of a glacial period all over Europe. Is it not reasonable to suppose, that the ice of that period entombed herds of animals which lived when the ice first accumulated, just as the Siberian ice does now, and that it was from similar sources the remains of the caves, and drift gravels were derived when the ice melted from time to time, as the glaciers retired northwards?

The period at which this took place can only be determined by ascertaining the probable date of the glacial period, or reckoning the period of maximum of glaciation; for we have still a continuance of the glacial period.

Mr. James Croll has suggested that the glacial period occurred in the northern hemisphere when it was in aphelion at the time of the maximum eccentricity of the earth's orbit, but having calculated for millions of years back he could not find when the two positions coincided; but he selected two periods —one 851,000 years ago and the other 210,000 years—as the most likely; finally, taking into consideration the small amount of denudation that has occurred, he selected the most recent, or 210,000 years ago, as the period when the maximum of glaciation occurred.

Mr. Gray was, however, more inclined to accept the theory of the French mathematician, Adhèmar, who has shown that the climatic effect of the obliquity of the earth's axis is sufficient to account for all the phenomena observed in connexion with the earliest evidences of man's existence, and also that the maximum of glaciation must occur in each hemisphere alternately every 21,000 years, and that therefore it must have occurred in the northern hemisphere 13,600 years ago. This would give sufficient time for the operation of those forces that moulded the superficial deposits immediately preceding man's advent; and the consequent climatic conditions,—a hot summer and very cold winter, with the attendant ice and flooded river action, and the possible migration of animals,—will fully account for all that has yet been discovered in connexion with the very earliest evidences of primeval man.